Vol. 22 April, 1929 No. 4

QUARTERLY

OF THE

National Fire Protection Association

For Members only, Annual Subscription $3.00.

Entered as second-class matter December 15, 1928, at the Post Office at Boston, Mass., under act of March 3, 1879.

60 BATTERYMARCH STREET, BOSTON, MASS.

National Fire Protection Association

INTERNATIONAL

Executive Office, 60 Batterymarch Street, Boston, Mass., U. S. A.

OFFICERS

F. C. JORDAN, VICE PRESIDENT
F. T. MOSES, VICE PRESIDENT
A. T. BELL, CHAIRMAN EXECUTIVE COMMITTEE
FRANKLIN H. WENTWORTH, MANAGING DIRECTOR
PERCY BUGBEE, ASSISTANT MANAGING DIRECTOR
ROBERT S. MOULTON, TECHNICAL SECRETARY

Organization Members

American Institute of Architects.
American Institute of Electrical Engineers.
American Society of Civil Engineers.
American Society of Heating and Ventilating Engineers.
American Bureau of Aircraft.
Arizona Equitable Rating Office.
American Concrete Institute.
American Electric Railway Association.
American Gas Association.
American Institute of Steel Construction.
American Marine Insurance Syndicates.
American Oil Burner Association.
American Paint and Varnish Manufacturers' Association.
American Petroleum Institute.
American Spice Trade Association.
American Water Works Association.
Arkansas Fire Prevention Bureau.
Asphalt Shingle and Roofing Institute.
Associated Factory Mutual Fire Insurance Co's. Inspection Department.
Associated Lumber Mutual Fire Insurance Companies.
Associated Metal Lath Manufacturers.
Association of Canadian Fire Marshals.
Association of Edison Illuminating Companies.
Association of Electragists.
Association of the Fire Alarm Industry.
Association of Fire Underwriters of Baltimore City.
Board of Fire Underwriters of Allegheny County.
Board of Fire Underwriters of the Pacific.
Board of Fire Underwriters of the Territory of Hawaii.
Board of Underwriters of New York, with which is incorporated the National Board of Marine Underwriters.
Boston Board of Fire Underwriters.
British Columbia Insurance Underwriters Association, Fire Branch.
Bureau of Explosives.
Canadian Automatic Sprinkler Association.
Canadian Fire Underwriters' Association.
Canadian Manufacturers' Association.
Cast Iron Pipe Research Association.
Central Actuarial Bureau.
Central Station Fire Protection Association.
Central Traction and Lighting Bureau.
Chicago Board of Underwriters.
Chlorine Institute, Inc.
Clay Products Association.
Common Brick Manufacturers' Association of America.
Compressed Gas Manufacturers' Association.
Cotton Insurance Association.
Eastern Underwriters Association.
Eastern Underwriters Inspection Bureau.
Electrical Porcelain Manufacturers' Association.
Factory Insurance Association.
Factory Mutual Laboratories.
Federation of Mutual Fire Insurance Companies.
Fire Equipment Institute.
Gas Products Association.
General Inspection Bureau.
Glass Container Association.
Grain Insurance Association.
Gypsum Institute.
Hollow Building Tile Association.
Hollow Metal Door and Trim Manufacturers' Association.
Hydraulic Society.
Idaho Surveying and Rating Bureau.
Illinois Fire Prevention Association.
Illinois Inspection Bureau.
Improved Risk Mutuals.
Indiana Inspection Bureau.
Institute of Makers of Explosives.
Institute of Radio Engineers.
Insurance Association of Providence.
International Acetylene Association.
International Association of Fire Fighters.
International Association of Municipal Electricians.
International Brotherhood of Electrical Workers.
Iowa Insurance Service Bureau.
Kansas Inspection Bureau.
Kentucky Actuarial Bureau.
Lightning Rod Manufacturers' Association.
Louisiana Rating and Fire Prevention Bureau.
Manufacturing Chemists' Association of the United States.
Michigan Inspection Bureau.
Millers' National Federation.
Mississippi State Rating Bureau.
Missouri Inspection Bureau.
Motion Picture Producers and Distributors of America, Inc.
Mountain States Inspection Bureau.
Mutual Fire Inspection Bureau.
Mutual Fire Insurance Association.
Mutual Fire Prevention Bureau.
National Association of Building Owners and Managers
National Association of Credit Men.
National Association of Dyers and Cleaners.
National Association of Engine and Boat Manufacturers, Inc.
National Association of Insurance Agents.
National Association of Mutual Insurance Companies.
National Association of Safe Manufacturers.
National Association of Sheet Metal Contractors of United States.
National Association of Steel Furniture Manufacturers.
National Automatic Sprinkler Association.
National Board of Fire Underwriters.
National Convention of Insurance Commissioners.
National Electric Light Association.
National Electrical Manufacturers' Association.
National Electrical Wholesalers' Association.
National Lumber Manufacturers' Association.
National Petroleum Association.
National Slate Association.
National Wholesale Druggists' Association.
Nebraska Inspection Bureau.
New Brunswick Board of Fire Underwriters.
New England Insurance Exchange.
Newfoundland Board of Fire Underwriters.
New Hampshire Board of Underwriters.
New Jersey Schedule Rating Office.
New York Board of Fire Underwriters.
New York Fire Insurance Rating Organization.
Nova Scotia Board of Fire Underwriters.
Ohio Inspection Bureau.
Oil Insurance Association.
Oklahoma Inspection Bureau.
Oregon Insurance Rating Bureau.
Pacific Coast Association of Fire Chiefs.
Philadelphia Fire Underwriters' Association.
Philadelphia Suburban Underwriters' Association.
Portland Cement Association.
Pyroxylin Plastics Manufacturers' Association.
Railroad Insurance Association.
Railway Fire Protection Association.
Sheet Steel Trade Extension Committee.
South-Eastern Underwriters' Association.
St. Louis Fire Prevention Bureau.
Tennessee Inspection Bureau.
Terminal Elevator Grain Merchants' Association.
Texas Inspection Bureau.
Texas Board of Insurance Commissioners.
Underwriters' Association of the District of Columbia.
Underwriters' Association of the Middle Department.
Underwriters' Laboratories.
Underwriters' Service Association.
The Union.
Virginia Insurance Rating Bureau.
Washington Surveying and Rating Bureau.
Western Actuarial Bureau (Fire).
Western Canada Fire Underwriters' Association.
Western Factory Insurance Association.
Western Insurance Bureau.
Western Sprinkled Risk Association.
West Virginia Fire Underwriters' Association.
West Virginia Inspection Bureau.
Wisconsin Inspection Bureau.

Over 4,600 Associate Members.

Table of Contents.

Boston Paint Warehouse Fire ..... Frontispiece

Editorials 357

Meeting of the Executive Committee 360

Drill Schools for Small Communities. *Activities of the Michigan Inspection Bureau* 367

Operation of the Holland Vehicular Tunnel. *W. F. Steffens* 373

Tank Car Fires 380

Flammable Vapor Indicators 388

Belt Dressings for Eliminating Static. *P. W. Edwards and J. O. Reed* 400

Fire Tests of Hollow Tile 407

Knoxville Gravity Tank Collapse. *Photographs from Tennessee Inspection Bureau* 415

Northern States Power Plant Fire. *James S. Mahan* 416

Garage Fire Record 422

Paramount Studio Fire. *Henry Anderson* 438

Fires in Which There Was Loss of Life 442

Annual Sprinkler Tables 445

Index to Volume XXII 458

Reports of fires appearing in the Quarterly are copies of or extracts from written reports forwarded to the Association. This Association, as a body, is not responsible for the statements or opinions of any of its members.

International.

A paint warehouse fire in downtown Boston on March 13, 1929, the twelfth fire in ten years in this large "block," divided by fire walls into sections separately occupied. Seven of the twelve fires were extinguished with small loss, but in five cases the combustible interior construction and unprotected vertical openings resulted in serious fires with an aggregate loss of approximately a million dollars. The occupants of four of the sections have learned the lesson of previous fires and installed automatic sprinklers. The fire shown above was in an unsprinklered section.

The Quarterly

Vol. 22 April, 1929 No. 4

The Thirty-third Annual Meeting. The thirty-third annual meeting of the Association, to be held at the Hotel Peabody, Memphis, May 13, 14, 15 and 16, will be the first meeting of the Association ever held in a Southern city. Unlike many organizations whose conventions are held in different parts of the country in recognition of various local groups, the National Fire Protection Association has quite consistently followed the routine of meeting in alternate years on the Atlantic seaboard and in Chicago. This is not an absolute precedent, however, and those whose activities in the Association date back a dozen years will recall the very interesting meetings held in Washington in 1917, in Ottawa in 1919, and in San Francisco in 1921.

The decision to go to Memphis was based on a desire to hold a meeting at a point which would be more accessible to our members in the South and Southwest, and also in recognition of the fire prevention activities of the City of Memphis. We originally planned to go to Memphis two years ago, but flood conditions and the hotel situation at that time necessitated shifting that meeting to Chicago and deferring the Memphis trip two years. The convention headquarters, Hotel Peabody, has excellent facilities for a meeting of the Association and ample accommodations for the members. While the meeting will be held in a different city among new surroundings, the primary emphasis will be as usual upon the committee reports and other serious business of the Association. The Memphis members promise an entertainment program which will reflect the renowned Southern hospitality, and everyone should be assured of a thoroughly good time.

The meeting in Memphis will appeal particularly to those of our members who combine attendance at N.F.P.A. annual meetings with their vacation trips, and will give them a glimpse of a section of the country totally different from that seen in going to Chicago or Atlantic City. Memphis will also afford opportunity for securing first-hand information on the cotton hazard, with which many of our Northern members have had no experience. As in the case of any convention, one of the most important advantages of attending a meeting of this kind is in the opportunity it affords to make contacts with men in similar lines of work from other parts of the country. This year, in addition

to the time at Memphis, there will be especially favorable opportunities for members to get together while traveling to the convention on the special trains from Chicago and New York. These parties, under the direction of Member James S. Mahan of Chicago and Member C. J. Peacock of New York, will give the members journeying to the meeting congenial company. It is hoped that all those traveling from the respective territories will arrange to join these special parties.

* * * * *

Reaching the Small Town. A comparatively recent development in fire prevention activity is the employment of an instructor by certain of the insurance rating organizations to visit the small communities in their territories and stimulate the proper organization and training of the local fire fighting forces.

A description of how this work is carried on by the Michigan Inspection Bureau is contained in this issue of the QUARTERLY. Other bureaus to perform this function include the Ohio Inspection Bureau, the Tennessee Inspection Bureau, and the Kentucky Actuarial Bureau. The work done so far indicates that eminently satisfactory results are being secured, and it seems probable that other bureaus will follow this practice. The service offered to the small communities under this plan is distinctly constructive and must inevitably lead to reduced fire losses and to substantially increased good will toward the bureaus.

* * * * *

Baltimore Clears Her Gangways. An ordinance became effective in Baltimore on March 8th eliminating parking from two of the principal narrow streets, Lexington and Fayette, in the central business district. Some 6,500 linear feet of roadway are thus to be kept free from automobile obstruction to traffic.

For a number of years the fire department of this city has advocated the elimination of parking on a number of downtown streets because of the inability of the department quickly to place its apparatus adjacent to a burning building on account of parked vehicles. Public attention was focused on the situation when on January 14, 1929, a fire occurred on narrow Lexington Street, in the very heart of the retail shopping district, at which it was necessary to sound eight alarms, and the fire department was delayed 20 minutes in getting its fire apparatus in action because of interference by parked vehicles. A few days later a similar delay of longer duration was experienced in connection with a fire on Gay Street, not far from the central business district.

As a result of the experiences at these two fires, the mayor's Traffic Committee advocated the elimination of parking on the above two downtown streets, and the ordinance to that effect was speedily enacted. To appease those merchants on these streets who believe they have a vested interest in con-

tinuing the conditions now abolished, comparisons of business volume are to be made after the ban has been operating for a month or two. The no-parking advocates, which include some of the merchants themselves, have contended that business conditions will be bettered by the new regulation because the majority of the machines are owned by persons who are not shoppers but are merely seeking a place to park while other business is being attended to.

In the elimination of the traffic evils with which Baltimore is now contending, may not all cities eventually be compelled to ask themselves what the fundamental purpose of a street is, anyway? Why should motorists stall their cars and go off and leave them in a busy street any more than a tired pedestrian should lie down on the sidewalk and take a nap? Both streets and sidewalks are for passing through, not repose.

The Blindfold Test

Whittlings.

Meeting of Executive Committee.

January 22, 1929.

The midwinter meeting of the executives was held in Atlantic City, January 22, 1929. The following members were present:

Albert T. Bell, Atlantic City, Chairman
Eugene Arms, Chicago
W. H. Blood, Jr., Boston
Geo. H. Greenfield, Montreal
W. F. Hickey, New Haven
C. T. Ingalls, Oklahoma City
W. E. Mallalieu, New York
S. D. McComb, New York
H. L. Miner, Wilmington, Del.
S. L. Nicholson, New York
J. S. Trump, Philadelphia
F. C. Jordan, Indianapolis, President
F. T. Moses, Providence, Vice-President
R. P. Miller, New York, Past-President
Dana Pierce, Chicago, Past-President
Franklin H. Wentworth, Boston, Secretary-Treasurer

Mr. A. R. Small, N.F.P.A. representative American Standards Association, was present by invitation.

Business Transacted.

The following members were elected under Article 4(c) to fill the offices indicated until the next annual meeting:

President, Frank C. Jordan, Indianapolis
First Vice-President, Frederick T. Moses, Providence
Second Vice-President, Sumner Rhoades, New York

The following members were appointed a committee to draft and present to the next annual meeting a memorial to Allen M. Schoen, who was elected president in May and died in August, 1928:

W. E. Mallalieu, New York, Chairman
W. H. Blood, Jr., Boston
S. L. Nicholson, New York

The report of the committee appointed to investigate the procedure of incorporating the Association (Franklin H. Wentworth, George W. Elliott, and S. L. Nicholson) was received. The committee was increased by the addition of W. E. Mallalieu and H. L. Miner, and instructed to make recommendation to the Executive Office with power.

Plans for the annual meeting, Memphis, May, 1929, were considered.

The Executive Office reported progress in securing QUARTERLY advertising. Assistant Managing Director Bugbee was given a vote of commendation for his work in successfully developing this project, and the committee appointed in January, 1928, to coöperate in initiating it was discharged with thanks.

Ways and means of obtaining new members were discussed, and helpful suggestions offered.

The special sub-committee of the Executive Committee appointed to give consideration to the organization of the Electrical Committee and the general

subject of its make-up, reported progress. The sub-committee was revised as follows:

W. E. Mallalieu, New York, Chairman
W. H. Blood, Jr., Boston
H. L. Miner, Wilmington
S. L. Nicholson, New York
Dana Pierce, Chicago

and requested to give further consideration to the matter and report to the Executive Committee.

An informal report on the present status of the American Standards Association was made by A. R. Small, N.F.P.A. representative.

An informal report of progress on the proposed Electrical Field Practice Manual was made for Victor H. Tousley, Electrical Field Engineer, by the Managing Director.

Technical Committee Business.

The following amendments to the regulations for Standard Industrial Buildings recommended by the Committee on Building Construction, after consideration of items referred back by the last annual meeting of the Association (see Proceedings 1928, pages 226-260), were adopted:

Title Page and Foreword

Make editorial revision to bring into form suitable for publication as a standard, rather than as a committee report.

(As these changes are purely editorial, they are omitted from this memorandum)

Article 5. Definitions.

Insert definitions, lifted from previously adopted reports of committee.

(These 23 definitions are omitted from this memorandum to save space)

Article 8.4.

Lumber and timbers used structurally in slow-burning heavy timber construction shall be of a commercial grade at least equivalent to the Basic Provisions for "Common" Structural Material prescribed in the American Lumber Standards. Minimum dimensions of lumber or timber, wherever specified in this report, refer to the standard trade (or nominal) sizes and not to the actual finished dimensions. (See Appendix XI.)

Article 11.22. 3rd line, delete "or fire window."

Article 13. Drainage. (See Appendix VI.)

Merchandise, stock and stored materials shall be protected from excessive water damage from any cause by means of interior floor drains, outlets and sumps, or scuppers. Such floor drains or outlets shall discharge into interior drainage lines, or into stair or other protected shaft enclosures, or through exterior walls by means of approved scuppers; such discharge to be provided in all stories in which water may be impounded.

The aggregate intake capacity, or cross-sectional area of outlets on any one floor shall be sufficient to promptly carry off not less than 75 per cent of the estimated water discharge in such story. Adequate provision shall be made for discharge at the lowest levels of all shafts and sumps to which water may flow.

NOTE: Reference is made to waterproofing of floors, Appendix VI.

Article 26.5 (and similarly Article 47.5) Exterior Walls:

Exterior, enclosure and panel walls shall be built of stone, solid or hollow brick masonry, hollow building tile of medium or hard grade or of approved concrete block all laid in cement-lime or cement.

Article 29.1

Reinforced concrete columns shall have a protection of concrete not less than 2 inches thick outside of the steel reinforcing. Such protection shall be placed monolithically with the concrete of the column. For concrete of which the coarse aggregate contains 50 per cent or more of quartz, chert, or similar minerals, the protective covering shall be not less than 2½ inches thick outside of the steel reinforcing, and shall be reinforced by steel mesh (openings not exceeding 3 inches) embedded not less than 1 inch from the outside finished surface. (See Note, Art. 70.)

Article 30.3

A minimum solid thickness of 4 inches shall be required for all reinforced concrete floors; when of ribbed tile and joist construction the total thickness shall be not less than 6 inches. (See General Requirements, Art. 13; also Appendix VI.) When a granolithic finish or topping is placed so as to be integral with the body of the slab, its thickness may be considered as part of the required minimum slab thickness.

Article 30.4 (and similarly Article 71.8)

Where surface wooden flooring is secured to sleepers, the spaces between shall be completely filled with incombustible materials up to the underside of the flooring, or to the underside of sub-flooring, where employed. (See Appendix V.)

Article 47.5 See revision as of Article 26.5

(New) Article 47.7 Parapets:

All exterior, party and fire walls shall have parapets not less than 3 feet in height above the roof. Such parapets shall be of reinforced concrete not less than 8 inches in thickness, or of masonry not less than 12 inches thick laid in cement mortar. Copings shall be securely attached to the top of parapets.

Article 51. Column Connections:

51.1 Timber columns shall be superimposed throughout all stories on reinforced concrete or metal caps with brackets or shall have ends connected by properly designed steel or iron cap, pintle and base-plate. (See Appendix IX. Wood bolsters may be used to support roof girders only.)

(New) 51.2 Column and girder connections shall be of construction, or be protected by fire-resistive materials affording not less than a 1-hour fire rating.

Change Article Numbers 51.2 and 51.3 to 51.3 and 51.4 respectively.

Article 53. Roof Construction. (See Appendix X.)

53.1 Roof Construction. Same as 1928 Report.

(New) 53.2 Cornices and facias shall be wholly of incombustible materials.

Article 67.5 Exterior Walls.

Exterior, enclosure and panel walls shall be built of stone, solid or hollow brick masonry, hollow building tile of medium or hard grade, or of approved concrete block, all laid in cement-lime or cement mortar, or of——.

Article 70.18

No pipes, ducts or wires shall be placed within the area required for fireproofing. This provision is not to preclude the use of small inserts or small conduit outlet boxes, provided the anchors for inserts and the pipes and conduits which supply such boxes are not located in the fireproofing.

Article 70.42

For concrete of which the coarse aggregate contains 50 per cent or more of quartz, chert, or similar materials, the protective covering shall be not less than 2½ inches thick, outside of the steel reinforcing, and shall be reinforced by steel mesh (openings not exceeding 3 inches) embedded not less than one inch from the outside finished surface.

Article 70.45

Delete text *in re* filled ("Lally") columns.

Renumber (printed report 1928) Art. 70.46 to 70.45.

Article 71.8

Same text and appendix reference as for Art. 30.4.

Appendix V. (New) Dryness of Slabs and Concrete Floor Filling.

Opportunity should be given or means provided for the thorough drying-out of floor slabs and of the floor filling required by Arts. 30.4 and 71.8. Otherwise, wood sleepers and flooring should be of treated lumber.

Transfer Definitions, formerly appearing in Appendix V, to Article 5.

Appendix VI. Water Damage.

Provision is made in Art. 13, Drainage (General Requirements), for removal of the large quantities of water which may obtain in extinguishment of fire or by accident, without which floors of timber, concrete and composite construction are subject to more or less leakage, and often cause large damage to stock and/or machinery in stories below. Valuable occupancies susceptible to water damage should be protected by waterproofing the floors above, especially when the latter contain fire hazards necessitating large quantities of water for extinguishment. To be effective, the waterproofing should be carried up at least 4 inches at walls and around pipes or other openings.

It should be noted that while the specification requires relatively thick floors, waterproofing is advisable where reasonable tightness is not assured by the construction.

Appendix IX. Column Cap Protection.

Attention is called to the fact that by far the weakest point in heavy timber construction, with respect to resistance to fire, is at unprotected metal caps and pintles providing the structural connection between timber columns and girders. Unless column caps are of reinforced concrete or other fire-resistive construction, or are protected by fireproofing as specified in Art. 51.2, serious damage by floor settlement or actual collapse may occur in severe fires.

Pintle, cap and base-plate construction depends, for stability of the floor construction, upon the bracing afforded by bearing walls; bracket caps of reinforced concrete, iron and steel mutually anchor columns and girders rigidly to each other.

Appendix XI. Lumber Standards.

The American Lumber Standards represent agreement between producers, distributors and consumers of softwood lumber, in collaboration with the U. S. Department of Commerce and Agriculture, as to recommended basic provisions for standard sizes and commercial grades. They were arrived at through careful study of construction needs and of practical lumber manufacturing possibilities and limitations. They should be made the basis, by manufacturers and consumers, of all commercial grades, specifications, and transactions involving softwood lumber.

Concrete Block.

Insert word "approved" before words "concrete block" in Arts. 26.5, 27.3, 47.5, 68.3.

It was voted to request the Committee on Building Construction to revise and bring up to date the Report on Fire-Resistive Construction published in 1918, now out of print.

At the request of the Committee on *Blower Systems* it was voted to adopt the following changes in the revised regulations on Blower Systems adopted at the last annual meeting of the Association (Proceedings 1928, page 166), in order to bring the text into harmony with the National Electrical Code, and eliminate an apparent misunderstanding with regard to the 143 note.

Provisions on electric power and control:

141. If power is by means of electricity the electrical equipment shall be throughout in accordance with the National Electrical Code.

142. **Wiring.** All electrical wiring within the rooms shall be installed in rigid or flexible metal conduits.

143. Motors, if used in connection with systems for the removal of flammable vapors (Class B) or for the removal of flammable dust (Class C) should preferably be located outside of the room from which such vapors or dust are being removed.

NOTE: Motors, switches, cut-outs and controlling devices, if within the rooms from which flammable vapors are being removed, should be located outside of the natural path of vapor travel.

Changes adopted in the above:

142. Omit.

143. Revise NOTE to read as follows:

It is recommended that where practicable, motors, switches, cutouts and controlling devices be not installed in locations where the atmosphere is charged or is liable to be charged with flammable vapors or where the circumstances are such that explosive conditions may result.

The Committee on Hazardous Chemicals and Explosives was authorized to release for publication, with minor amendments, its proposed "Table of Hazardous Chemicals." (Proceedings 1926, page 60; 1927, page 59; 1928, page 183.)

An item from the Flammable Liquids Committee on the use of washing machines for dry cleaning operations was referred to the Executive Office.

It was voted to request the Committee on Gases to bring in a report on regulations for mechanical refrigeration equipments to the next annual meeting if, within the next sixty days, the A.S.A. Sectional Committee now considering this subject does not complete a revised report satisfactory to the N.F.P.A. committee.

It was voted as the sense of the committee that it is inexpedient to publish in the News Letter paragraphs relating to employment.

It was voted to create a Committee on Aviation with Samuel D. McComb of New York as chairman. The following were appointed members of the committee:

H. L. Miner (Chairman, Committee on Flammable Liquids)

H. P. Weaver (Chairman, Committee on Protection of Records)

F. T. Moses, Associated Factory Mutual Fire Ins. Cos.

Captain E. E. Aldrin, Aviation Department, Standard Oil Development Company. (Chairman Aeronautical Division, A.S.M.E. Member National Advisory Committee for Aeronautics)

First Lieut. Albert C. Foulk, U. S. War Dept., Wright Field, Dayton (officially designated by Dept.)

C. S. Fliedner, U. S. Navy Dept. Bureau of Aeronautics, Washington (officially designated by Dept.)

Harry H. Blee, Chief of Airport Section, U. S. Dept. of Commerce, Washington (officially designated by Dept.)

The Executive Office was authorized to add to the membership of this committee in conference with the chairman thereof.

Committee Revisions.

The following revisions in committee personnel were approved:

Building Construction:

J. Miller Porter (replacing H. J. Schweim), Gypsum Institute

Construction Operations:

Wm. B. White, New York Board of Fire Underwriters, Chairman

Dust Explosion Hazards:

L. F. Adams (replacing R. W. E. Moore), National Electrical Manufacturers Association.

Hylton R. Brown, Secretary, U. S. Department of Agriculture

Peter Steinkellner, International Association of Fire Chiefs & International Association of Fire Fighters

Electrical:

A. C. Brueckman, Association of Electragists, International

F. V. Magalhaes (replacing J. P. Jackson), American Institute of Electrical Engineers

H. N. Pye, South-Eastern Underwriters Association

Electrical Field Service:

Laurence W. Davis (replacing A. Penn Denton), Association of Electragists, International

Electric Power Houses:

Louis Harding, Chairman

James S. Mahan, Secretary

C. M. Gilt, National Electric Light Association

H. N. Pye, South-Eastern Underwriters Association

W. B. Sims, National Electric Light Association

Electric Railway Car Houses and Cars:

Louis Harding, Chairman

James S. Mahan, Secretary

H. N. Pye, South-Eastern Underwriters Association

Farm Fire Protection:

W. D. Brinckloe, American Institute of Architects

G. H. Schaeffer (replacing Robert A. Jones), National Association of Farm Equipment Manufacturers

V. H. Tousley

Flammable Liquids:

H. N. Pye, South-Eastern Underwriters Association

Garages:

J. V. Macartney, National Automatic Sprinkler Association

Hazardous Chemicals and Explosives:

N. G. Burgster, Western Actuarial Bureau

Manufacturing Risks and Special Hazards:

Henry A. Fiske, National Automatic Sprinkler Association

John R. Hamilton, National Automatic Sprinkler Association

Marine:

M. M. Brandon (replacing E. P. Slack), Underwriters' Laboratories

August Emrich

Protection Against Lightning:

Morton G. Lloyd, Chairman

Safety to Life:

Dan C. Boney (replacing Stacey Wade)

John Irwin Bright (replacing W. O. Ludlow), American Institute of Architects

Salvaging Operations:
Guy F. Elliott (replacing R. W. Wight)
Signaling Systems:
M. M. Brandon (replacing E. P. Slack), Underwriters' Laboratories
H. W. Hadlock (replacing G. S. Lawler), Associated Factory Mutual Fire Insurance Companies
Frank V. Sackett, National Automatic Sprinkler Association
Zoning:
Clifford Davis (replacing Thomas H. Allen)
A.S.A. Committee Appointments:
Sectional Committee on Brick Masonry, Clinton T. Bissell, Fire Protection Group Representative
Sectional Committee on Hose Couplings, A. M. Houser, N.F.P.A. Representative

---

Intelligence the Basis of Moral Progress.

By Willis O. Robb.

It is the simple truth that more conscience, more productive, world-forwarding conscience, requires primarily more intelligence; not more good-will nor more righteousness, but more knowledge better reasoned out. Conscience without enlightenment may serve as a basis for a religion, but not for a civilization. For civilization is at once broader and more exacting than religion. It will not hear its children say "We have done our best," if admittedly their best has not been good enough. "You must better your best," it says to them. Think of the utterly devoted old-time physician who gave his life to his work, but who knew nothing whatever of the modern germ theory of disease, and innocently went on his way killing as many curable patients as he cured. I knew an old dentist who had specialized in root-fillings for thirty years, and who, when the X-ray at last revealed to him that eighty per cent of his work had been imperfect, threw down his tools forever. He had done his best, and it was not enough. It is not true that "what you don't know won't hurt you." It may ruin you forever. So far as the progress of the world is concerned it is even more important that a man should increase in knowledge of what is right, and why it is right, than that he should merely do the best he knows without trying to know better. Muddy thinking makes muddy morals. We must see straight in order to walk straight.

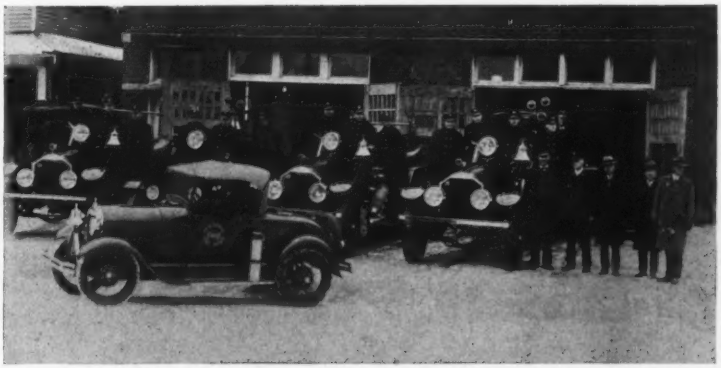
Drill Schools for Small Communities.

Activities of the Michigan Inspection Bureau.

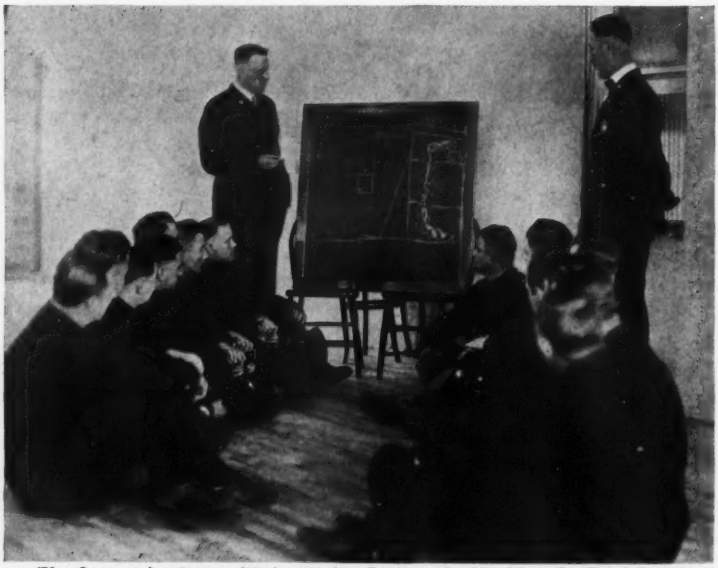
While fire department drill schools and fire colleges are in operation in various parts of the United States and Canada, they are for the most part located in the larger cities and are attended almost exclusively by members of paid departments. For the smaller communities these facilities have not been readily available, and it remained for the Michigan Inspection Bureau (Member N.F.P.A.) to establish a fire fighting school which would extend to the smallest hamlet within its jurisdiction.

The plan was first put into operation in July 1927, more or less as an experiment, as the result of a suggestion that an attempt be made to increase the efficiency of the small fire departments of the state, particularly the volunteer organizations. These smaller departments have not been in a position to obtain up-to-date information on modern fire fighting methods, and the plan was to train them as far as possible in an elementary way in the effective handling of apparatus and equipment, drill school operations, salvage methods, inspections, fire hazards, rescue work, first aid, and arson investigation.

From the first the plan was enthusiastically received. Scores of requests for inspections and drills came in—more than could be handled. As news of the service spread the demands increased, and departments which had been instructed sent requests for return visits and further training.



Ferndale Fire Department. A typical department visited by the Michigan Inspection Bureau's "schoolmaster."



The firemen in class, with instructor Just at the blackboard. Chief Smith of Ferndale is looking on.

As a result of this cordial reception of the work and with the realization that here was a form of service that returned very tangible results, the Michigan Inspection Bureau announced in December last that this work would become a permanent part of the Bureau's activities. Perhaps later on advanced classes in fire fighting can be instituted for volunteers who have graduated from the primary classes.

This service is offered to any town or village in Michigan if the municipal authorities will agree to four things:

(1) Extend the Bureau an official invitation to make the inspection of their department.

(2) Recruit the department to full strength—to 12 men per volunteer company.

(3) Make the necessary arrangements to have each member present at every drill.

(4) Promise full coöperation of both municipal officials and the fire department.

Perhaps the best way to describe the operation of the school is to follow the instructor in a typical town. The first meeting is called to order at the

Lowering a fire victim in a rope sling.

firehouse at 7 o'clock Monday evening. Every man is required to come dressed to fight a fire, or in uniform, if the corps has uniforms.

The first lesson consists of taking each and every piece of equipment possessed by the company and explaining carefully what it is for and how it is used. Every man present is required to handle it and it is made sure that each man understands what it is for. One of the most common faults with small departments is the unfamiliarity of the men with the various pieces of equipment, and for this reason this seems an ideal starting point.

When the equipment has been put back in place, and perhaps correctly located for the first time since the organization of the company, the rest of the evening is spent in a lecture discussion of company organization, specific duties of various members of the company, the need for absolute discipline, and the duties of a fireman. In this lecture is also included instruction on the handling of ropes, tying of knots, etc., and their application to the use of hose lines and other fire department work.

Tuesday afternoon the ladder drill begins. The men are drilled in raising and handling ladders, how to climb them, how to use roof lines and hand lines in reaching difficult places, how to lower people from upper stories with ropes,

how to carry hose lines to upper stories and roofs, how to stretch chemical lines, and how to use and recharge small extinguishers.

In the evening another session is held. At this meeting instruction is given in first aid, rescue work, artificial resuscitation, etc. The lecture by the instructor also includes the care and use of smoke and gas masks and life lines, advice on how to detect suspicious fires and gather evidence of arson, explanation of the problem and theories of ventilation, a discussion of automatic fire control devices, how to make inspections, and the detection of fire hazards.

Wednesday morning, accompanied by the fire chief, the instructor addresses the local high school students, and then, as time permits, visits other schools, making brief fire prevention talks. At noon he appears before a luncheon attended by leading citizens of the town.

In the afternoon the department is again assembled and the matter of handling hose lines and directing streams of water on fires is taken up. The instructor demonstrates the proper way to stretch hose, how to make connections, how to lay double lines, how to use hose tools, how to direct and handle heavy streams of water with and without special appliances, how to use life lines, and how to slide down ropes in an emergency.

Catching a fire victim in a life net. The picture was taken during a snowstorm.

A lesson in "splicing" two short ladders to reach the roof of a building too high for either one.

Thursday is inspection day. In the morning, in company with the officials of the department, an inspection is made of the town, pointing out the principal fire hazards, recommending changes, giving advice on how to remedy particularly bad conditions. The rest of the day is spent in checking over the equipment of the department and preparing a list of recommendations.

All sorts of conditions have been found. Sometimes chemical extinguishers are found useless or empty, ladder locks have been found defective, making possible a serious accident should it have been necessary to use them, hose lines have been found full of pin holes or rotted, ladders broken, and even pumping equipment has been found rusted and useless. Inadequate or improper equipment is a very frequent condition.

One very common fault has been to find the couplings of hose lines screwed up so tight that it is almost impossible to uncouple them. After the last fire an inexperienced man has coupled the lines together and it is quite natural for him to screw the couplings up tight when he does so. After they have lain in the hose truck for three months it is almost impossible to loosen them. What he should do, of course, is to attach the lines by just screwing in a couple of threads, then when the hose is taken out for use the couplings will not be "frozen."

Sometimes the results of these visits have been unexpected and startling. Fire departments in some towns were found to be entirely inadequate and were completely reorganized. Eight towns felt obliged to purchase new fire trucks, and thirty-five or more bought other kinds of equipment. One hundred and ninety-five volunteers were enlisted and nine paid firemen were employed as a result of the instructor's recommendations.

In the eighteen months since this service has been available 153 towns have been visited, 82 of them more than once. Ninety-five complete drills have been held, 1823 firemen instructed, 365 inspections of towns made in company with local fire officials, and 18 addresses outside of fire department talks given. In addition to this, the instructor, as sort of a side-line, is reaching from 700 to 1500 school children each week with advice and warning about fire safety.

A fair example of the results possible is the situation in Niles, Michigan, a town of 12,000 inhabitants. The fire department had just four men and no ladder truck. The instructor asked for a special session of the city council, which, after investigation, appointed a special citizens' committee. When this committee got through its work, Niles had a new fire station, a new department of 12 paid men and a chief, new equipment including a ladder truck, and it had one man detailed to make constant inspections of the buildings of the town in the interest of fire prevention. Last fall the Chief attended the Detroit Fire Department drill school in order to acquire more advanced knowledge of fire fighting.

Niles was just one of the ten reorganizations of old departments and seven organizations of new departments which have been accomplished. St. Joseph, Mich., is another. In St. Joseph there came a day when the entire membership of the old volunteer fire department resigned—and within three hours an entirely new full paid department stepped into its place.

Operation of the Holland Vehicular Tunnel.

By W. F. Steffens,
(Member N.F.P.A.).

If any single word were indicated to describe the qualifications necessary for an engineer, that word would be *vision*. In establishing vehicular connection between the Island of Manhattan, New York City, and the State of New Jersey at Jersey City, the Holland Tunnel has provided an indispensable facility, a monument to the vision of its projectors. When this method of communication was first suggested, considerable incredulity existed as to the practicability of operating a tunnel of total length about 9200 feet with traffic exclusively of gasoline-propelled vehicles, the exhaust from the engines of which would constantly vitiate the surrounding atmosphere with carbon monoxide and other products of combustion. In addition to this incredulity, there also existed an unspoken fear that fires in these vehicles would create an additional hazard to property and life. Hence, in the July QUARTERLY of 1926, an attempt was made to present some of the physical features of the design of the tunnel, and the provisions being made for adequate ventilation and fire protection facilities.

This project was actually placed in operation November 12, 1927, since which time various descriptive articles have appeared in the technical press and elsewhere regarding various features of the structure and its facilities. Particular reference is made to the article of Mr. Ole Singstad, Chief Engineer and Superintendent, in the *Engineering News Record* of December 27, 1928, in which article complete physical data as to operating conditions, including traffic density, ventilation and lighting, are given. Some of the general statistics will be used at this time in order to visualize the extent of the operating problem presented, as well as the cases of traffic interruption experienced, including those in which fire extinguishing equipment was used.

The tunnel consists of two tubes each about 9200 feet long, the north tube for westbound and the south tube for eastbound traffic. The roadways are 20 feet wide between curbs, and on grades varying from 0.25% in the main or under-river section, to 3.80% on the approaches. The fresh air supply through continuous slot each side of each roadway is from a duct formed between the flat surface of the roadway and the circular section of the tunnel beneath it. The exhaust is through grille protected openings in the flat ceiling spaced about 15 feet on centers, with considerably closer spacing toward the exits. The exhaust duct is in a corresponding space to the fresh air duct, but betwen the flat ceiling and the curved section of the tube. The design of the

A previous article by the same author in the QUARTERLY for July, 1926 (Vol. 20, No. 1, p. 53), describes the construction of the tunnel and the plans made for fire protection and safety to life.—ED.

An interior view of the tunnel, showing the driveway separated into two traffic lanes by the white band. The fresh air supply slots are just above the curb; the gases are exhausted through ceiling openings. At this point of the tunnel these openings in the ceiling are 15 feet on centers. The foot walk is at the left. One of the safety niches is shown just beyond the man who is at a telephone panel. Between the man and the safety niche the two narrow vertical openings contain single fire extinguishers. On the opposite wall the double door is at the opening where five foam extinguishers are kept. The lighting system by lamps behind ground glass panels provides diffused illumination.

roadway and ventilating equipment was based on a maximum capacity of 1900 vehicles per hour through each tube for mixed traffic, and 2540 per hour if all passenger cars. The estimated tunnel traffic for 1928 was 8,500,000 vehicles of all kinds. The ventilating system provided for a total movement of 3,760,000 cubic feet of fresh air per minute, based on a concentration of carbon monoxide not to exceed four parts in 10,000 parts of air during capacity operation. Longitudinal movement of gases from automobiles theoretically would not exceed 15 feet before these gases were seized by the incoming fresh air movement, and exhausted at the nearest ceiling outlet. The division of each tube into seven sections for ventilating purposes, or 14 sections for the two tubes, required 28 separate duct sections, each handled by three fans, two of which when operating at full speed would be sufficient to provide the necessary ventilation, with the third fan kept in reserve.

With these general physical characteristics in mind, as well as the capacities for which the tunnel was designed, it is interesting to note what has

actually been experienced since the formal opening on November 12, 1927. The novelty of this artery for traffic between two states resulted in the passage of practically 52,000 vehicles on the first day of operation, with a maximum hourly traffic in the south tube of 2371 vehicles, and in the north tube 2225 vehicles. Subsequently, traffic fell to a more normal daily average of somewhat over 20,000 vehicles, with the second highest traffic record on September 9, 1928, the Sunday following Labor Day, with about 48,000 vehicles passing through both tubes. Even during these maximum periods the ventilating system has functioned practically as contemplated by the design. Delicate mechanism reveals automatically to the chief supervising operator at all times the carbon monoxide content of the air passing through the exhaust ducts. Should this at any moment exceed the allowed maximum, and manifest itself through the automatic signal provided for the purpose, the fans are speeded up until normal conditions are restored. A sequence of a considerable number of large vehicles, such as commercial trucks and buses, on the roadways invariably results in the discharge of an excess of carbon monoxide, but this is taken care of as described. Future operating conditions may require further regulations as to the type of vehicles entering the tubes if their engine capacity is not sufficient to maintain a minimum speed of six miles per hour on the adverse grades at the exits. These adopted grades, however, have been justified as suitable to the average traffic.

Prior to the opening of the tunnel certain operating rules were established in the interest of safety, convenience of operation, assuring maximum capacity of the roadways and continuous operation, even with failure of certain vehicles. Weights of vehicles were limited to 15 tons capacity, and the overhang of the body to 9 inches in excess of the wheel rims. No vehicle wider than 8 feet nor of greater height than 12 feet can enter except under special permit. Horse-drawn vehicles and metal tires are excluded. Explosives, flammable or corrosive liquids and poison gases or liquids are excluded. Materials such as hay, excelsior, or, in general, baled combustible material, any part of which may escape from the vehicle, must be covered by tarpaulins firmly secured. Vehicles are assigned to a traffic lane in accordance with their relative speeds, the right-hand lane being used for heavy vehicles at lower speeds than the left-hand lane, which is for passenger automobiles and those capable of 30 miles per hour, which is the maximum allowed speed. After being assigned to a given lane, a vehicle is not permitted to leave it or to cross the marker or dividing line unless by permission of a policeman. Tire changing is not permitted in the tunnel by drivers. Headlights must be extinguished when entering. Vehicles must maintain a spacing of 75 feet.

To establish rules and make them effective a supervisory organization is an essential detail. At the tunnel a complete police department performs this function under the jurisdiction of a chief inspector, three captains, fifteen

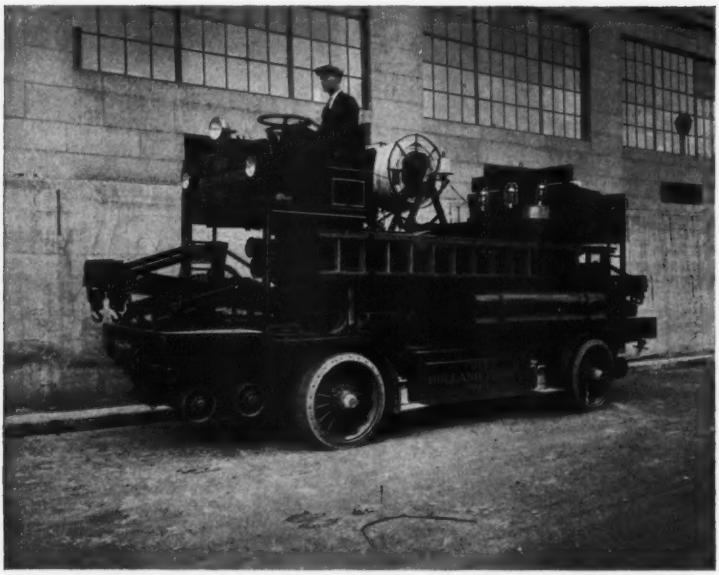
Telephone, fire alarm and fire extinguishers are in recessed cabinets in the tunnel wall. The inset shows a typical extinguisher cabinet with four 5-gallon and one 2½-gallon foam extinguishers. An electrical heating grid maintains the temperature at 70° F.

sergeants, policemen, plaza ticket men, and an adequate office staff, to a total of somewhat in excess of 200 men. Policemen serve alternately two hours in the tubes and two hours on the plaza approaches to a total of eight hours. They are organized and drilled through roll calls and inspections in the same manner as municipal police departments. Added efficiency results from frequent talks between officers and policemen. Before being accepted for final assignment to duty, each man is trained to establish familiarity with his duties and to promote a feeling of public confidence in ability of the staff to handle any emergency, including breakdown of vehicles and fires. Familiarity with fire in automobiles is assured by conducting tests under operating conditions, during which excelsior on a truck is saturated with gasoline and allowed to burn about one minute. At the time of the test fire the gasoline tank of the vehicle must be filled. In using the extinguishers the men are rehearsed to fight the fire with foam extinguishers so as to drive the fire away from the gasoline tank.

In the previous article it was stated that for the control of fires that may occur in vehicles, portable extinguishers of the foam type and capacity of five gallons and two and one-half gallons are provided, 120 feet apart, in which distance at least eleven such extinguishers will be available, while others can be brought quickly from more remote points. Larger supplies of foam can be furnished through generators on the emergency trucks or wrecking cranes, located at the tunnel approaches. Sand can be secured every 240 feet of roadway length, and 2½ in. fire hose affords a larger supply of cooling water should the necessity require it. For the operation of such large numbers of gasoline-propelled vehicles through four lanes of traffic, it was anticipated that breakdowns and fires would occur, but these must be taken care of quickly and

efficiently to avoid traffic delays. When a vehicle is disabled the effectiveness of training of the organization is immediately realized. The nearest policeman appraises the condition and promptly reports to the supervising operator. Immediately yellow signals are displayed in that tube, ordering vehicles to establish single traffic lane from the point of breakdown or fire to the exit. Entrance of additional vehicles is immediately reduced until normal conditions are restored. At this point the advantage of the 75 feet spacing between vehicles is emphasized, for in the spaces thus provided the vehicles in advance of the point of obstruction can be transferred to the other lane. In the lane thus cleared between the point of obstruction and the exit, the towing tractor or the large truck, according to the magnitude of the case, can proceed in the direction opposite to traffic to the vehicle to be assisted. In this way the delay is reduced to but a few minutes, but incidentally, a condition is avoided in which large quantities of carbon monoxide will have to be taken care of due to stalled traffic. Even this extreme condition has been anticipated, for red signals can be displayed in the tunnel bearing the instruction *Stop Engines.*

To the fire protection branch of the engineering profession the most interesting single detail will be the number and kind of fires that have been actually experienced and the method and time of extinguishing them. In the first calendar year of operation 178 fires were recorded, and in the first three months of the present year there have been 42 fires. Of these, however, about 90% are due to overheated brake bands. Instructions contemplate that while on the descending grades motors shall operate in gear, but chauffeurs frequently disengage the engine, depending entirely on the brakes to prevent undue acceleration. Frequently, brake bands thus set on fire are not noted by the chauffeurs. Vigilant police, both on patrol or mounted on motorcycle, note these cases and proceed to extinguish such fires. Due to the vertical draught induced by the ventilating system, the upward tendency of these fires damages the body of the vehicle. Police patrolmen at the entrance to the tubes also frequently detect steaming radiators, burning insulation, or excessive exhaust from vehicles prior to entering the tunnel and thus prevent delay by excluding these until the proper remedy has been applied. While in the seventeen months of operation a total number of about 300 fires have been recorded, it is notable that these have always been handled by the portable type extinguishers, so that it has not been necessary to use the foam generator on the wrecking truck. This is silent testimony to the efficiency of the patrol organization in promptly detecting and attacking fires. One fire, in which a bus carrying sixteen passengers was involved, which was apparently due to back-fire, required the contents of only three of the five-gallon extinguishers. This was handled in less than two minutes, following which the burning insulation in the electric wiring was extinguished by a $1\frac{1}{2}$-quart carbon tetrachloride extinguisher operated from beneath the vehicle. In another instance a truck, loaded with



The fire truck. It contains the fire protection equipment, including a continuous foam generator and the hose to serve it. It has a boom at each end operated by gearing, so that the truck may be used as a wrecking crane either at the front or the back.

three bales of excelsior, experienced fire at the engine due to back-fire. Prompt application of the foam extinguishers to the blaze extinguished it without any damage to the excelsior.

A complete card record is maintained for every disabled vehicle or fire, giving all of the physical data, including the name and address of the owner and of the operator, the type of car, the nature of the case, whether collision, fire, breakdown, number of passengers, if that type of vehicle, method of extinguishment if a case of fire, personal or property injury occasioned, cause of breakdown or fire, and in what way the disabled vehicle was assisted out of the tunnel. The value of such a consecutive record can be realized in view of the very frequent use of this traffic artery by commercial firms, bus operators, and others. The question naturally arises as to punitive steps that may be indicated in the case of breakdown or fire. The regular tariff for that vehicle is doubled for that service. For the average truck up to capacity of ten tons, with a toll charge of $1.00, the imposition of a charge of an additional $2.00 for towing or fire extinguishment is merely nominal. An entirely different case is that when the gasoline supply of a vehicle becomes exhausted so that replacement is necessary in the tunnel. In this event a charge of $1.00 for one gallon of gasoline is exacted. Several hundred gallons of gasoline have been

sold in spite of this unit price that is frankly imposed to produce a deterrent effect. When it is considered that in the first twelve months of operation this tunnel provided passage for over 8,500,000 vehicles, about evenly divided between eastbound and westbound, with a daily average of over 23,000, and an average Sunday and holiday traffic of over 36,000, the number of breakdowns and fires that have occurred, and the slight delays to this enormous traffic that have been experienced, afford silent testimony to the vision of those who conceived this project, and to those who, through application of sound engineering principles and judgment, translated the vision into a successful operating traffic facility.

Acknowledgment is gratefully given at this time for the courtesy of Mr. Ole Singstad, Chief Engineer and Superintendent of the Holland Tunnel (member of the American Society of Civil Engineers), in furnishing the data from which this brief article has been prepared, and to members of his staff who have supplied direct testimony as to the high state of efficiency of the operating organization.

Testing of Dry Valves.

Extract from report of an inspector of the New York Fire Insurance Exchange.

Valves No. 1 and No. 2 tripped properly with water flowing from test pipe.

Valve No. 3 tripped BUT we failed to get water from test pipe due to an obstruction. The test pipe and the piping leading to same was removed and found to contain dirt, excelsior and paper. Upon close examination of this paper it was found to be in *Jewish print*. Needless to say that a chorus of laughter followed this find. It was shown to the superintendent of the premises, who stated "Tenk God, dis is truly a *Kosher* sprinkler system."

A second tripping of the dry pipe valve was perfect, with all *Kosher products* removed.

Tank Car Fires.

The losses chargeable to the transportation of explosives and other dangerous articles on the railroads of the United States during 1928 were ninety-five per cent due to flammable liquids, according to the statistics of the Bureau of Explosives (member N.F.P.A.). The Bureau of Explosives, acting under authority delegated by the Interstate Commerce Commission, prepares the regulations governing the railway transportation of explosive and flammable and other dangerous materials, and maintains an inspection and reporting service which gives full information on all fires and explosions occurring in connection with railway transportation of hazardous materials.

The relation of losses due to flammable liquids and other dangerous articles during the year 1928 is shown by the following table compiled by the Bureau of Explosives:

Comparative Summary Showing Railway Transportation Losses Chargeable to Explosives and Other Dangerous Articles in 1928.

Class	No. of Accidents	Persons Killed	Persons Injured	Property Loss
Explosives	12	0	0	$ 77
Acids and Corrosive Liquids	423	0	17	13,156
Flammable Liquids	624	15	16	777,140
Flammable Solids and Oxidizing Materials	101	0	0	22,660
Compressed Gases	50	0	73	3,643
Poisonous Liquids and Solids	7	0	0	289

The Bureau comments on these losses as follows:

The preponderance of flammable liquid cases is no longer news. For 1928, as shown by the table, the record for these liquids has risen to more than 95 per cent of the total of losses occurring in the transportation of dangerous articles. There are simple reasons for this. In the first place, due mainly to the enormous consumption of gasoline, a far greater tonnage of flammable liquids is being shipped than of any other class of hazardous material. In the second place, the commodities in this class are more or less volatile liquids, ready to take advantage of every opportunity for leakage, and because of their volatility, quick to evaporate and mix with air, in which state ignition is very easy and usually incredibly destructive.

Of all flammable liquids, gasoline is firmly intrenched as leader, because of the amount shipped. Property losses involving gasoline are practically 91 per cent of the total for flammable liquids generally, for 1928; these gasoline losses being about 87 per cent of the total for all dangerous articles. As in past years, however, derailments account for the greatest bulk of the loss. Considering all gasoline fires for 1928, 26 are shown in the summary on a following page, with a loss figure of $664,707. Of this, practically 98 per cent, or $649,385, was a matter of wreck and derailment. The remaining 2 per cent, or $15,322, is but a small proportion of the whole, but even in this balance practically two-thirds is chargeable to two cases of rough switching almost in the wreck class. It must also be remembered that in the general loss figure for gasoline other derailments, not followed by fire, are included but not separated.

As far as flammable liquids other than gasoline are concerned, the total of loss involved in their transportation, taking fires and simple leakages together, was $67,319.00. While

this may in itself be regarded as a considerable sum, it is small as compared with the total attained by gasoline alone. Even here derailments played a significant part, primarily due to the large single unit container which the tank car actually is. The fact, however, that a material loss, coupled with several personal injuries, did occur in cases which did not involve wreck or derailment, makes it plain that the hazard afforded by the derailment is greater only because of the greater probability of large leakage, and that containers much smaller than tank cars, be these containers drums, bottles or cans, must be regarded as likely sources of trouble if leakage, especially when followed by ignition, should occur.

Summary of Fires in Transportation of Gasoline in 1928.

JAN. 2. INWOOD, IOWA. Tank car lying on side with safety valve broken off and gasoline leaking out after being involved in derailment of freight train. Gasoline ignited in unknown manner. Loss $26,750, 3 injured.

FEB. 4. THORNDALE, PA. Gasoline leaking from auxiliary pipe ignited when car passed over an ash pit. Loss $3.

FEB. 21. MERIDIAN, MISS. Gasoline splashed out of dome cover, which was too small for the threads to engage, while being switched in freight yard. Loss $1.

MARCH 15. MILLERTON, IOWA. Derailment of freight train followed by fire. No dome cover or bottom outlet failures reported. Loss $26,260.

MAY 9. BEAVER DAM, OHIO. Car not placarded "Inflammable" contained leaking drum of gasoline. When conductor entered car with lighted lantern vapors ignited. Loss $1.

MAY 13. CLARKSFIELD, OHIO. Freight train derailed due to broken oil box bolts. Tank cars had holes punched in them, leakage from which ignited from friction sparks. Loss $17,850.

JUNE 7. ARKADELPHIA, ARK. Defective brakes caused derailment of freight train. Four cars of gasoline had damaged shells, leakage from which ignited, due to friction sparks. Loss $6,080.

JUNE 15. HADLEY, PA. Freight train derailed because of emergency application of air brakes. Friction sparks ignited leaking liquid. Loss $100,000.

JULY 13. CURTIS BAY, MD. Dome cover of tank car, which was roughly handled in switching, was not in place and some gasoline slopped out at the the dome. Vapors ignited from near-by switch lamp. Loss $1.

JULY 16. SPENCER, OHIO. Sudden setting of the brakes caused derailment of freight train. Gasoline tanks opened up and leaking gasoline caught fire from friction sparks. Loss $107,568.

JULY 22. MATFIELD, KANSAS. Following derailment of freight train, leakage was ignited by friction sparks. No available information on damage to bottom outlets, etc. Loss $45,260.

JULY 23. SHUQULAK, MISS. Car connected to unloading pipe and left unattended for night. Freight train arrived during night with hot box; this car set out on house track breaking unloading connections. Conductor examining hot box scooped up leaking gasoline, thinking it was water, and threw it in the box, resulting in fatal burns and destruction of large quantity of gasoline. Loss $622, 1 killed.

JULY 29. GUERNSEY, WYO. Derailment of freight train caused by washout. A number of tank cars were burst open and leaking gasoline ignited from friction sparks. Loss $55,000, 8 killed.

AUG. 13. PARKER, KANSAS. Freight train derailed by draw bar wedged in track. Leakage due to shell punctures and seam leakages ignited by friction sparks. Loss $66,000.

AUG. 15. PAULINE, TEXAS. Freight train derailed, due to brake rigging down. Leakage due to outlet boots being broken off, valves unseated and shell holes ignited. Loss $1,250.

AUG. 24. GREEN VALLEY, MINN. Derailment caused by broken rail. Friction sparks ignited leakage from bottom outlets, safety valves and dome cover joints and seams. Loss $36,901.

SEPT. 1. CLEVELAND, OHIO. Dome cover came off tank car while cut of cars was being switched. Gasoline splashed out and ignited from near-by switch lamp. Loss $76.

SEPT. 6. UPTON, INDIANA. Tank car fell to bottom of ravine when bridge collapsed, causing shell to break open. Leaking gasoline was ignited by friction sparks. Loss $100,000.

OCT. 2. ST. JOSEPH, ILL. Tank car placed for unloading and not protected by stop sign. Tank car struck by an empty car, breaking unloading connection. Conductor with lighted lantern came along and attempted to check the flow, but vapors ignited. Loss $75, 1 injured.

OCT. 3. BEAUMONT, TEXAS. Cut of cars, including four tanks of gasoline, handled rather roughly and gasoline was found escaping from one tank due to splitting of end sheet. Vapor ignited from a switch lamp while switching around to get the leaking car out. Loss $4,150.

OCT. 5. ZYBA, KANSAS. Freight train derailed because of a broken rail. Tank car had hole punched in side and more than 15 other tanks had side sheets punctured, outlet boots broken off and valves unseated. Leakage ignited. Loss $37,466.

OCT. 27. TOLEDO, OHIO. Car overturned in yard collision, car wrecked and contents burned up. Another tank caught fire due to seam leakage, but soon extinguished. Loss, estimated, $5,000.

NOV. 19. NEW YORK CITY. Tank car next to caboose in train was crushed in when rear end collision occurred. Leaking gasoline was ignited from either lamp or fire in the caboose. Loss, estimated, $3,000, 1 killed.

NOV. 22. WINCHESTER, VA. Tank car was being unloaded when yard engine struck the tank, breaking pipe connection, allowing gasoline to flow out. Ignition, probably from fire box of yard engine, quickly followed. Loss $5,393.

DEC. 9. DALHART, TEXAS. In head-on collision between a fast passenger train and freight, a tank car was damaged and leaking gasoline ignited. Tank car had head punched in. Loss, estimated, $15,000.

SEPT. 4, Est. SPARTANBURG, S. C. While cut of cars was being switched, it was pushed violently against another cut. Shell of leading tank car was torn open and contents ignited. Loss $5,000.

Accident Bulletins.

The Bureau of Explosives issues Accident Bulletins at intervals through the year for the purpose of educating railroad employees as to safe practices in the handling of dangerous articles, and focusing attention upon the important regulations of the Bureau. These bulletins are written in a semi-humorous style which brings out the human interest features in an interesting way. Two of these bulletins, dealing with tank car fires, are reproduced on the following pages.

What's a Life Worth?

19-7622.....July 29, 1928.....Gasoline.

Here's an interesting picture. Aside from the fact that it portrays a marvelous mess, it shows several tank cars the contents of which are serenely burning at the safety valves, something that happens fairly often, but usually when there's no camera handy. It shows there was a fire, and also a wreck; but there's more to the story than the picture shows, just as there was more to the fire than you can see in the picture.

It isn't our purpose to hold a discussion on the fine points of distinction between a tramp and a hobo, or any other varieties of side-door-Pullman voyagers. Nor are we going to dwell on the dangers to railroad property from having these gentry distributed along a freight train. Among other things, we intend to uphold a new argument (at least, we think it's new) for the complete absence of hoboes, tramps and trespassers-by-any-other-name, from any and all parts of any train not designed for passenger transport.

What value do you put on the life of one of these misfits? Of what use are they? Certainly they aren't of much benefit to the railroad, even though many of them are, or may pose as, itinerant harvest-hands. Anyway, we doubt somewhat the ability of the average brakeman positively to identify them as one sort or the other.

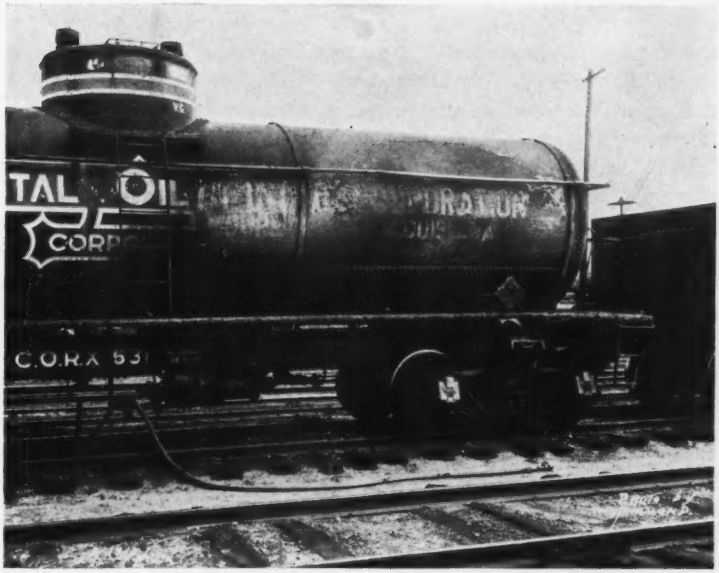
Here we have a freight train consisting of 94 loads and 2 empties—quite a train, at that! On account of a lot of water that came down out of the sky pretty much all at one time and place, the roadbed at that point was in pretty soft shape, certainly too soft for a heavy train. The engine and nearly half the train managed to pass the soft spot before the track settled and piled up the

rest of the train in an untidy mountain. Of the entire 96 cars, 73 were loaded with *gasoline,* and a very liberal proportion of these were in the part that piled up. Bent and torn tank shells permitted gasoline enough to run out to carry every taxicab in the country from one traffic light to the next. The grinding of metal on metal as the cars came together evidently furnished plenty of sources of ignition. Flames shot up on all sides. Gasoline streamed down to a near-by river and spread, blazing on the surface of the water, giving everybody for miles around premature gray hairs—they must have thought the world was coming to an end.

We mentioned the fact that there were two empty boxcars in the train. These were among the cars which were so completely burned up that there wasn't much left to tell what they had been. Now, in taking stock of all damage after the fire, we find that a number of "trespassers"—call 'em anything else you wish—who were on the train at the instant of the wreck, could not be found. From the habits of these gentry, where else would they be but in the two empty boxcars? Unsuspecting men, taking their ease in a boxcar, don't leap to safety from a crash they can't foresee; so if those fellows were in one or both of the cars, they *never did get out!* We don't know just how many there were, but it's believed there were about eight. Naturally, nothing remained afterward, so fierce was the fire.

Now, seeing that there was no evidence of these unfortunates *after* the fire, how do we know there were any on the train? It could only be that some or all of the train crew knew these trespassers were aboard. Some brakemen have no use for tramps—would even go as far as to throw one off a fast-moving train—that doesn't sound pleasant, but it's been done. Some other brakemen, kindly fellows, sympathize with the wanderers, or at least tolerate them, out of sheer goodness of heart, or for other reasons, and let them ride. A long while ago, a case was written up in which a brakeman was so anxious to find a place for Weary Willie to ride that he helped Willie into an empty tank car, from which the tramp never did come out alive!

We'll agree, first of all, that these "gentlemen of the road" have no legitimate place on a freight train. Secondly, we must admit that they could not ride the train without the connivance or indifference of the crew. Thirdly, the present case and the other one mentioned are two of many instances where it proved to be *mighty poor kindness* to let 'em ride. They may be of no use—they may be pests—but they're human beings for all that. Furthermore, if we are going to make any distinctions at all, there's no place for trespassers on a train having *73 cars of gasoline* in it.



When Fate Conspires.

19-7611.....July 23, 1928.....Gasoline.

There's supposed to be nothing new under the sun. That's probably so true that it might as well be extended to include the moon and the stars. Still, while things happen that have happened many times before, now and then we find combinations of these old standbys which prove to be unique in themselves. At such times it seems as though fate was conspiring so successfully that no possible way of having things go wrong was left out. So, we turn now to a real tragedy so amazingly complete in its succession of errors that it almost puts on the mask of grim comedy, as though some evil spirit had been holding high carnival.

First, we have the stage set upon a siding, the house track of a local station. Alongside this track was the unloading plant of a gasoline service station. Opposite the unloading-point stood a tank car, the one shown in the picture above. Apparently this gas-station hadn't been in existence so very long, for this was only the third tank car to be placed here for unloading by these people.

The car was delivered during the afternoon, but for some reason, or none, it was not connected up for unloading till about 7 P.M. By this time the local freight agent had gone off duty for the day. The oil people evidently figured that there'd be nothing doing on the housetrack that night, so they hooked up their unloading-pipe to the bottom outlet of the tank car and let 'er run.

Paragraph 1050 (A) of the I. C. C. Regulations, B. W. Dunn's Tariff No. 1, requires the protection of a connected tank car by putting up a blue and white *Stop* sign; but the oil company in question apparently didn't own such a sign. Paragraph 1050 (M) requires that there must be some employee of the unloader in attendance all the while the tank car is connected to the unloading line. These folks, after talking over among themselves the seemingly remote possibility of any switching on the house track that night, decided to go home to bed. Now, the stage setting was completed.

While the through freight was rumbling across country that night, somebody noticed a hot-box on a gondola loaded with gravel. There seemed to be quite a young blaze going on in the box. Well, no use trying to haul anything like that across country; so as soon as possible the train halted at the nearest siding, which was the house track already described. Preparations were made then and there to cut out the gravel car and shove it on the house-track, where the sizzling journal could be allowed to cool off while the train went on. The tank car was too near the switch to allow room for another car, so the gravel car was shoved in against the tank car to move the tank farther along. *It moved,* and you can just guess what happened to the unloading pipe! There were some 1500 gallons of gas in the tank at the time, and the 1500 proceeded quietly out on the ground and into the ditch. The brakeman who was handling the movement then took a look to make sure the tank car wasn't obstructing a near-by road-crossing, and then turned away to uncouple the gravel car, and signaled to pull the main string back on to the main track.

When the train was again made up the freight conductor thought he'd better go take a look at that hot box and see just what shape it was in. He poked up the box-lid. Probably the packing was still smoldering. Thinking the near-by ditch was full of water, he dipped up a handful and poured it into the box. *Instantly* there was a flash. The unfortunate conductor had not a chance. He was rushed to a hospital, but was too badly burned to pull through.

Just glance at the picture. By looking closely you can trace the extent of the fire where it scorched the paint on the tank and the wood on the gondola. The picture was not taken at the scene of the accident, as you might guess from the number of tracks; but the two cars are shown coupled as they were when the flash went off.

A bushel basket would hardly hold all the lessons to be learned from this fire, but it will be worth our while to stop and look at the most significant ones. As far as the oil people were concerned, they were either ignorant or too indifferent to carry out the two requirements already described.

The local freight agent, a competent, energetic, busy man, who had not previously had any great quantity of gasoline unloaded near his station, had not become familiar with the necessary precautions for unloading tank cars. Had he known these rules and understood their importance, he would not have

permitted the oil people to handle their unloading operations in such a free and easy manner.

How about the train crew? Since there was no *Stop* sign ahead of the tank car they had, technically, no reason to hesitate in coupling up to it; *but* —these pages have in times past been decorated with tales of broken unloading connections. Stop sign or no stop sign, it's a risky game to couple to a tank car, *especially at night,* without taking a few seconds to look for connecting pipes hitched either to the dome or to the bottom outlet of the tank car. This isn't a criticism of the crew—*it's a word to the wise!*

Next, when the coupling occurred the tank car moved forward; the gondola moved over at least part of the spot where the tank had stood. By the time the brakeman, who must have been riding the gravel car, dropped off to uncouple the car from the main string, the ground and pretty much everything else must have been soaked with gasoline. Did he smell it, or did he think that the odor of gasoline was only to be expected around a tank car? The fact is, gasoline vapor has *no business* in the open air at any time. If you smell it, *particularly* around a tank car, something's wrong!

In the same way the conductor mistook the gasoline for water; perhaps the odor of the hot box kept him from smelling the gasoline vapor, but the two odors are *nothing like* each other. At certain intervals railroad trainmen must undergo physical examination. Their eyes and hearings are examined; why not their noses too? This is *not* funny—it's mighty serious. Suppose you were walking along the highway and an automobile dashed suddenly around a curve. You saw it, jumped aside, and were safe, where a blind man would have been struck down. Now assume that you're sitting at home, reading. The windows are closed because the night is cool. A leak of illuminating gas occurs. Do your eyes notice it? Can you hear it coming? *No!* If you don't *smell* it, you're a *goner!* Many people have a poor sense of smell. Better find out now whether you're one of 'em. If you are, you have to be ten times as careful. If you're not, you have no excuse for not being careful.

1. *Don't* bump a tank car you know nothing about.
2. *Don't* think the smell of gasoline means nothing.
3. *Don't* leave that rule book on the shelf gathering dust.
4. *Don't* forget Nos. 1, 2 and 3.

Flammable Vapor Indicators.

The unseen fire hazard is always more difficult to control than the obvious hazard, and among the unseen fire dangers that of flammable vapor is particularly insidious because there has been no convenient method of detecting or measuring it. Wherever flammable liquids are used there is always the potential hazard of fire or explosion of the vapor, but with methods heretofore available it is often a very difficult matter to determine whether or not flammable vapors are present in dangerous quantities. The sense of smell readily detects the presence of some vapors but cannot be depended upon to differentiate between a safe and an unsafe atmosphere, particularly in the case of the interior of tanks, ovens and similar spaces. Sampling of the air and determination of the flammable vapor content by chemical analysis is a slow and laborious process. This has been largely used in determining the vapor content of ships' oil tanks prior to sending men into them for repair operations and in connection with certain industrial processes, but this method has obvious limitations.

As a result of recent developments there are now available instruments to determine the percentage of flammable vapors present in the atmosphere. These instruments may be used to determine quickly and conveniently the percentage of flammable vapors present and should be of very great value in controlling the fire and explosion hazard, in regulating ventilation to maintain a safe atmosphere, in determining that large oil tanks are in a safe condition for repair operations, and in other various ways. Three different instruments have been independently developed; one by the Factory Mutual Laboratories, one by the Standard Oil Company of California, and one by the Union Carbon and Carbide Research Laboratories. All of these instruments depend for their operation upon the heating effect due to the burning of a small sample of the atmosphere under analysis, this heating effect being measured electrically and giving a reading on a dial. As the details of the three instruments vary materially, and they are designed for different fields of use, they are described separately in this article.

The flammable vapor indicator developed by the Factory Mutual Laboratories is described in some detail in the text reprinted here from the Factory Mutual Record. This instrument is designed for continuous operation, has a high degree of accuracy, and incorporates features which overcome the effects of various factors which might interfere with the accuracy of the reading. The gas is drawn through this instrument by means of a motor operated suction fan, the motor being of a special type which maintains a constant speed irrespective of voltage fluctuations, and which may be operated from the ordinary

Factory Mutual Record.

This damage is the result of an enamel oven explosion several years ago. The F.M. Flammable Vapor Indicator was developed to prevent explosions such as this by controlling the flammable vapor content.

A.C. or D.C. lighting circuit. A heating coil prevents condensation in the instrument and permits its use in connection with high temperature ovens. This device is available as a continuous recorder of the flammable vapor content or for automatic regulation of ventilation in order to keep the flammable vapor content at a safe figure. While the instrument was developed originally for use in ovens, it is manifestly useful in numerous other applications. The Factory Mutual Laboratories, while controlling the patents on this device, have arranged to make it available to the public and it is now available commercially.

The instrument developed by the Standard Oil Company of California, which is described here in detail in extracts from a paper by Mr. H. H. Hall, Chief Engineer of the company, presented at the last annual meeting of the American Petroleum Institute, is designed primarily for determining the vapor content of oil tanks. The sample of gas is drawn through the instrument by means of a manually operated rubber bulb. Electric current is supplied by a battery. This instrument does not incorporate all of the refinements mentioned in the preceding paragraph, as they are not necessary for the purpose intended. This instrument is portable, convenient for use in oil tanks, and should perform a very useful function. As this is primarily a safety device, the

Standard Oil Company of California does not plan to exploit it in any way and has made arrangements to make it available to other oil companies and the public generally.

The combustible gas indicator developed by the Union Carbon and Carbide Research Laboratories is not described in detail in this article, as this device is not yet commercially available. This instrument differs from the other two in that instead of drawing a sample of the gas through a tube to the heating element, the element is lowered into the tank or other space where it is desired to determine the atmospheric conditions. This element is protected by a fine wire flame arrester similar to that used on miners' lamps. An electric cable connects this portion of the device to the battery and meter case which the operator carries. This instrument should be a very useful detector. Compared with the method of drawing the gas through a tube to the element, this instrument has the limitation of depending for its reading upon diffusion of the gas through the screen to the element. Gases such as hydrogen and acetylene have burning characteristics such that a screen suitable for use with other gases may not function, and for this reason the device is not recommended for hydrogen and acetylene. Current is supplied by a portable storage battery. This device was first developed as a methane indicating detector for use in coal mines, and used later for determination of the safety of the atmosphere in oil tanks, and for this purpose appears to be a very useful instrument.

The F.M. Flammable Vapor Indicator.

From Factory Mutual Record.

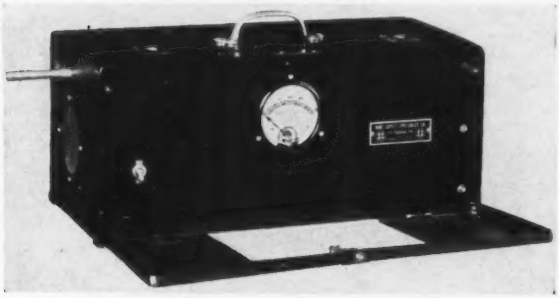
The onward march of industry brings new processes and new hazards. To eliminate the hazards and safeguard the processes is the constant challenge to fire protection engineering.

One of the major problems today is the prevention of explosions in enamel baking ovens.

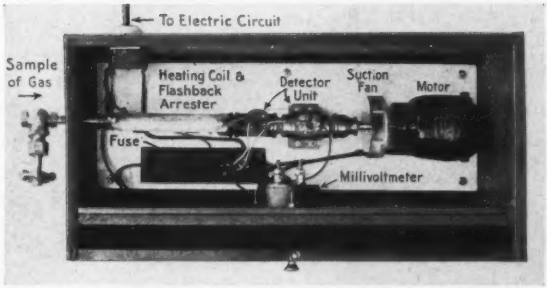
The most important essential is to control the oven ventilation so that the flammable vapors of the enamel are kept below the lower explosive limit. Removing or guarding sources of ignition, such as open flames or electric arcs, is important; but this alone will not prevent explosions, since an explosive mixture under certain conditions can be set off merely by the surface heat of the gas-burner boxes, radiator tubes, or electric-heating ribbons.

Control of oven ventilation, heretofore, has been more or less a hit-or-miss affair, because no one could tell quickly the exact concentration of vapors in the oven. The usual laboratory methods of gas analysis require a half hour or more for results and in that time conditions in the oven might change entirely.

To meet the need for a device giving immediate and continuous results, the Factory Mutual Laboratories, after two years of study and research both



The F.M. Flammable Vapor Indicator.

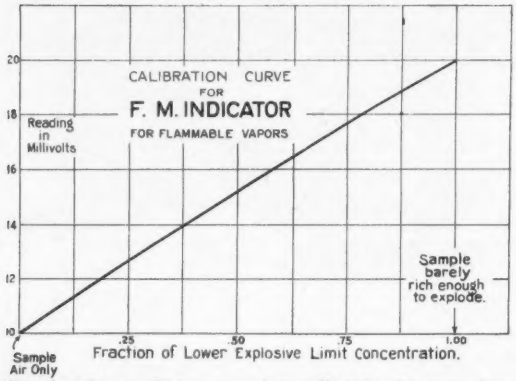


Top view of the F.M. Flammable Vapor Indicator with cover off, showing component parts. The suction fan draws the sample of gas through the heating coil, flash-back arrester, and detector unit.

in the laboratory and under actual operating conditions in industrial plants, have developed the F.M. Flammable Vapor Indicator, which promises to provide a check for the safe control of oven ventilation.

The device is essentially a continuous calorimeter, in that it burns the vapor and measures the heat given off. A continuous sample of atmosphere from the oven is drawn by a small fan, first through a heating coil which keeps the sample at oven temperature to prevent condensation, and thence through a flash-back arrester to the detector unit. Here an electric-heating coil ignites the vapor in the sample, and the increase in temperature is measured by a thermocouple and is indicated on a millivoltmeter. The reading is then referred to a calibration curve which gives the percentage of vapor in terms of the lower explosive limit.

The Indicator records without special calibration for the various hydrocarbon gases, alcohols, and ethers, either alone or in combination, since flammable compounds containing carbon and hydrogen, or carbon, hydrogen, and oxygen, give off approximately the same amount of heat when burned at the



The Calibration Curve. This curve shows directly, for any given reading on the millivoltmeter, the percentage of vapor in the sample in terms of the lower explosive limit.

lower explosive limit. Special calibrations are needed for hydrogen, carbon monoxide, and acetylene.

The device can be set for an ample factor of safety, and can then by the use of relays be made to ring an alarm, turn on a red light, start the ventilating fans, control the speed of the fan motors, operate the dampers, turn off the oven heat, or perform any other function suited to particular conditions. Not only is it suitable for enamel baking ovens, but also for recovery processes, for coating processes, such as imitation leather, rubber spreading, or cloth waterproofing, and for any processes where flammable vapors may collect in an enclosed space.

A Simple Gasoline Vapor Indicator.

Extracts from paper by Mr. H. H. Hall, Chief Engineer, Standard Oil Company of California, presented before meeting of American Peiroleum Institute, December, 1928.

To oil men it hardly seems necessary to offer any proof of the fact that explosive mixtures of petroleum vapor and air are sometimes found in other places besides the cylinders of an engine. However, we have a few pictures to illustrate some of the other places where such things do occur. These also graphically emphasize the importance and value of the new instrument to be described. Most of these pictures originated on the Pacific Coast; but that is not because ample material of a similar nature could not be gathered in other parts of the country.

These accidents are not isolated instances but have occurred with surprising frequency considering the generally high standard of safety maintained by substantially all oil companies. One of the principal contributing causes in the past has been the difficulty and uncertainty of determining the real character of various vapor-air mixtures. The sense of smell depended upon by many

Fig. 1. This tanker was thought to be clean and sweet before it was put on dry dock and repair work started. The picture shows the results of the vapor explosion which followed.

workmen, and to a certain extent by technicians, is a most unsatisfactory criterion. Some hydrocarbon vapors can hardly be detected at all in this way. In the recent past the most common scientific method has been to have a chemist actually sample the contents of a container about which there was some question, analyze this sample, and from his knowledge of the amount of this particular hydrocarbon necessary to produce an explosive mixture, offer an opinion as to the danger or lack of danger existing in the container. This, in turn, was quite unsatisfactory, not only because it required a considerable amount of time, but because unless a great many samples were taken one could never be sure that in remote corners of the ship or tank entirely different mixtures did not exist. Ships' tanks are particularly noteworthy for their odd shapes and inaccessible corners. In order to be sure that no explosive mixture exists in some one of these out-of-the-way spots, it has been necessary to carry the cleaning process to a great extreme. At times, as the pictures indicate, the extreme has not, however, been great enough.

The wide field of usefulness and great value of a simple instrument which would "smell" any atmosphere and tell immediately how dangerous it was has

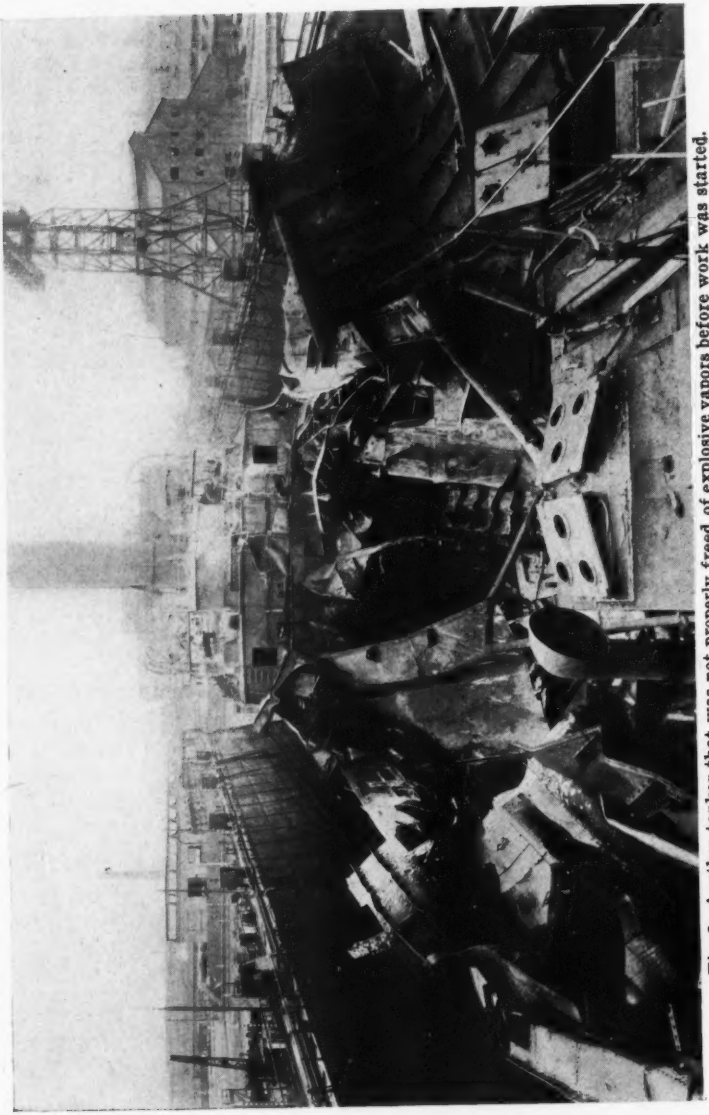


Fig. 2. Another tanker that was not properly freed of explosive vapors before work was started.

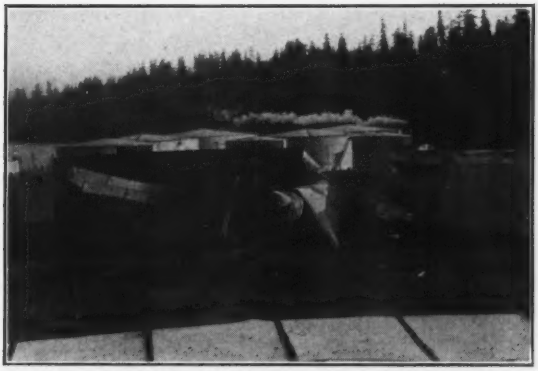


Fig. 3. A shore tank which was being cleared. This was thought to be safe, but an explosion occurred with the results shown.

been apparent for a long time. It remained for two chemical engineers in the Engineering Department of the Standard Oil Company of California to actually build such an instrument. They adopted an old principle which had been suggested for the determination of similar conditions in mines, but which, as far as we can find out, has never been in common use. However, the principle appeared to be good and our men proceeded to actually make an instrument. This first instrument has now been in constant use for about a year and a half and is giving entire satisfaction. About 90 others have been manufactured and used by other departments of our company and, to a limited extent, by other companies,—so far without any difficulty. The instrument is easily portable and tells instantly on a plainly marked scale how near the vapor-air mixture comes to containing enough hydrocarbons to be explosive.

The compact simplicity of the apparatus is shown in Fig. 7, in which one of the inventors is demonstrating its use. Fig. 4 is a top view of the instrument. A hose leading to the point where the analysis is desired is attached at "A"; and the bulb "B" is used as an aspirator to draw a sample through the hose into the instrument and on out to the air. The relative amount of petroleum vapors in the sample passing through the instrument is indicated by the deflection of the needle on dial "C."

Fig. 6 shows the general principle on which the instrument works. A sample of the vapor from the space being investigated is drawn through the tube "X," in which is placed a platinum wire which is normally heated to a bright red by electric current from dry cells enclosed in the case. If the gas sample contains combustible hydrocarbons, they will burn at the surface of the platinum filament—this process being what the chemists speak of as a catalytic effect. The additional heat furnished by this combustion will raise the temperature of the filament and thus increase its resistance, which in turn

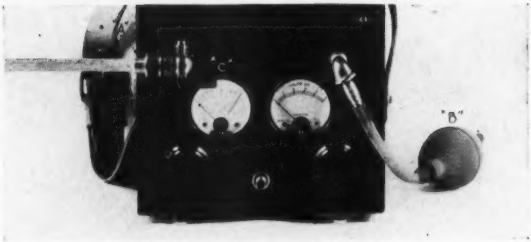


Fig. 4. A top view of the instrument.

Fig. 5. A close-up of the scale on which the degree of explosibility is read.

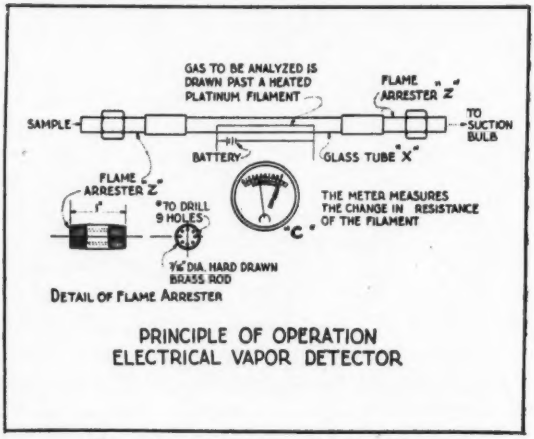


Fig. 6. Principle of operation of detector.

will cause the pointer to move over the indicator dial ("C"), which is marked to show directly the amount of hydrocarbon vapor in the sample. To insure that there is no chance of combustion being transmitted from this reaction chamber into the space being sampled, flame arresters ("Z") consisting of brass rods with very fine holes drilled through them longitudinally are placed on either side of the reaction chamber.

If the results of an analysis are reported as so many per cent of gas, it is impossible to know whether that concentration is dangerous or not unless the *kind* of gas is also known. A 3 per cent mixture of methane with air would not be explosive—while a mixture containing that amount of gasoline vapors would be violently explosive. It is usually very difficult to tell exactly what kind of gas is present in any particular place, so an instrument which makes this knowledge unnecessary has a great advantage.

It should be pointed out that the instrument is not adapted to the measurement of mixtures above the lower explosive limit. Pumping such mixtures through the instrument is likely to melt the fine platinum wire catalyst, necessitating its replacement.

Referring again to the close-up view of the indicator dial (Fig. 5), a further explanation of just how this dial is graduated may be of interest. Different hydrocarbon vapors must be mixed with air in different porportions to produce an explosive mixture.

In the case of motor gasoline vapor, these proportions range from about 1½ per cent to 6½ per cent of gasoline vapor in air by volume. Three per cent produces about the maximum explosive mixture; this is the most desirable mixture for automobile cylinders. When the amount of gasoline vapor gets up to 6 per cent, the mixture is so "rich" that it will produce a very slow muffled explosion; and above 6 per cent it will be so rich that it will not burn in a closed container no matter how many sparks or flames are produced inside the container. Such a rich mixture will, of course, burn as a torch when it is expelled from the container into the atmosphere, where it can mix with enough air to burn. Down at the other end of the explosive range, when the mixture has been diluted so that it contains only 1½ per cent of gasoline vapor by volume, it will be so lean that only a weak flash is obtained when ignited. It is this lower explosive limit that is designated by "1" on the indicator scale. In other words, when the pointer on the indicator is on "1," the sample being drawn through the instrument contains just enough hydrocarbon vapor to be at the lower explosion limit. As indicated by the red* coloring of the dial above this point, the presence of any more hydrocarbon—which will deflect the instrument pointer above 1—means that the mixture may be in the explosive range and hence dangerous. The scale between "1" and "0" has been divided into 10 equal parts. Thus, if the hand stands at .2, the sample being tested contains only one-fifth enough gas to be explosive. Bureau of Mines'

Fig. 7. Using the instrument for investigating conditions in a tanker before sending men in for cleaning operations.

tests indicate that vapor concentrations approximately one-fifth of the lower explosive limit may be toxic for men to work in. This figure varies considerably with different individuals and with the length of time at which they may be exposed. A few breaths of mixtures considerably richer than .2 might not be harmful, but for long time exposure this is about the maximum which can be breathed without danger. Hence, this portion of the scale between .2 and 1 has been colored yellow* to call attention to the fact that it may be unsafe for breathing, although not explosive. Below .2 the mixture will be safe both for men to work in and to use open flames.

This method of measurement gives the apparatus a unique advantage, in that it has a "universal explosibility scale." This means simply that regardless of the *kind* of gas which is present (whether gasoline vapor, heavy vapor from

*Note: In the half-tone cut, red shows black, and yellow shows gray.

hot fuel or a heavy distillate, or the light gases, predominately methane, which are sometimes found in refinery tanks or around natural gasoline plants)—to repeat in *spite* of any such difference, the meter hand always indicates the "nearness to explosibility." The importance of this will be realized when it is pointed out that the lower explosive limit for hexane is only about 1.2 per cent by volume, while for methane it is six and a quarter per cent.

Fig. 7 shows the instrument used for investigating the conditions of a tanker prior to letting men go in for cleaning operations. The hose is let down through the ullage hole and readings taken every few feet from top to bottom of tank; thus in the course of a minute or two a complete "cross-section" of the vapor conditions in the tank can be obtained. Again a sample may be pumped continuously while the end of the hose is moved about, and the existence of abrupt changes in composition (as pockets of rich gas) readily noted. For instance, the hose may be gradually lowered into a tank while pumping, and a traverse made of the whole tank.

One other desirable feature of the instrument which has not been mentioned is that the operator can always be assured that it is in working condition. Every time the bulb is squeezed, drawing air through the instrument, the meter hand fluctuates slightly, even though there is no hydrocarbon vapor present. This little flutter of the hand *proves* to the operator that the machine is in operating order. No accident, such as a loose connection, breakage, burn out, etc., can render the machine inoperative without also destroying this fluctuation. This fact is a great help to the operator who uses the machine for the first few times, because he is likely to find that some space which *smells very* gassy actually contains less than a tenth of the explosive quantity. The sense of smell has proven entirely unreliable. Without some visual indication such as this to prove that the machine is working he might be inclined to conclude that it had broken down.

It is hardly necessary to point out the manifold uses of such a device. While primarily intended to be used as an aid in tank cleaning, it also finds use in general survey work, in routine testing of cargo space, 'tween decks, etc., on ships, and at numerous points around refineries. One of these instruments was used at Santa Fe Springs during the long battle to subdue the burning Getty No. 17 well.* Here it served to check the condition of the air in the tunnel leading down to the casing, as a protection against the accumulation of dangerous quantities of gas, which is occasionally found in pockets at that depth.

*See QUARTERLY, January 1929, p. 283, for a description of this fire.

Belt Dressings for Eliminating Static.

By P. W. Edwards and J. O. Reed,

Bureau of Chemistry and Soils, U. S. Department of Agriculture.

It is a well established fact that static electricity is a frequent source of ignition for gas explosions and fires. For years it was thought that static electricity was the cause of a number of dust explosions and fires, but until 1915 sufficient evidence was not obtained to prove conclusively that static electricity under certain conditions can ignite dust clouds. That year the United States Department of Agriculture made an investigation to ascertain the cause of numerous explosions and fires during the threshing of wheat in the Pacific Northwest.* Much of the wheat was infected with a cereal disease, *tilletia tritici*—commonly called stinking smut, the spores of which are very small and form explosive mixtures when suspended in air. The results of the department's investigations indicated that the smut clouds were ignited in most cases by static discharges within the threshing machines. Owing mainly to the very low relative humidity during most of the threshing season, static electrical charges were detected on the machines at all times while in operation. Potentials as high as 65,000 volts were measured on the drive belts. As a result of the investigation measures were recommended for controlling this fire hazard, and the department has no record of an explosion or fire in any threshing machine equipped and maintained in accordance with these recommendations.

How Static Electrical Charges Are Generated.

Static electrical charges are generated on power transmission belts in three ways, (1) the friction of the belt on the pulley, (2) the separation of the belt from the pulley, and (3) to a less extent by the friction of the atmosphere on the belt. On conveyor belts the charges are generated by the same means and in addition by the friction of the conveyed material on the belt.

Static charges on machinery are caused by one or more of the following: (1) induction, (2) transmission from other sources, such as drive pulleys, and (3) the friction of material passing through the machine.

Under normal operating conditions a large part of the charge on a belt is generated by the separation of the belt from the pulley. Under certain conditions, if two dissimilar materials in contact are separated, a static charge is produced on each object. The polarities of the charges on the objects are opposite and depend on the nature of the material. If the two objects are insulators, the charges remain on them for varying lengths of time, depending upon the relative humidity of the atmosphere and the degree to which it is

*U. S. Dept. of Agriculture Bulletin No. 379, page 9, "Dust Explosions and Fires in Grain Separators in the Pacific Northwest," David J. Price and E. B. McCormick.

ionized. If the two objects are electrical conductors, the charges will be removed as soon as they are electrically grounded.

In the case of a revolving metallic pulley and belt, as a definite portion of the belt is pulled away from contact with the pulley, a static charge resides on that portion of the belt and an equal and opposite charge is on the pulley. Since the belt is not an electrical conductor the charge remains on the belt, but since the pulley is a conductor the charge that was generated on it distributes itself over the whole pulley and every part of the machine or shaft that is electrically connected to it. If the machine is electrically grounded no charge will remain on the pulley or machine, but a charge will remain on the belt. If the machine is insulated from the ground the potential of the machine will gradually build up as additional charges are generated on the pulley. The rate that the potential builds up on the machine depends upon a number of factors, such as the electrical capacity of the machine and the atmospheric conditions around it.

Methods for Eliminating Static Electricity.

Considerable time has been devoted by a number of investigators to devising methods for the elimination of static electrical charges from belts and other objects. Most of the methods are effective if properly maintained, but inspections have shown that very often they are ineffective because of neglect. Frequently this increases the hazard rather than eliminates it.

Grounding systems have been very popular. They consist in electrically connecting and grounding all metallic parts of a machine and in placing grounded metallic combs in contact with the belts at positions within a few inches of the points where the belt leaves the pulleys.* The main disadvantages are that the wires are sometimes broken and that often, in attempting to ground the circuit, the electrical resistance of the soil is so great that it prevents the removal of the electrostatic charges from the belt or machine.

Another method for eliminating electrostatic charges consists in humidifying the air to the extent that an invisible film of moisture covers all objects. This film acts as an electrical conductor and either removes the static charges as rapidly as they are formed or prevents their formation. Curtis has shown† that "the surface resistivity of most materials changes through wide limits when the humidity of the surrounding air is varied. It is often a million times as great at low humidity as at high humidity." Humidification is not applicable to all conditions where static charges may be formed, for in the manufacture or handling of a hygroscopic material it may be inadvisable to maintain a humid atmosphere in the plant. The amount of humidification required to remove electrostatic charges has been determined for only a few materials.

*Dust Explosions, Price & Brown, N.F.P.A., Boston, 1922, p. 150.

†Bureau of Standards Bulletin No. 234, Insulating Properties of Solid Dielectrics, p. 417.

A method sometimes used for removing electrostatic charges from paper passing through a printing press consists in applying a gas flame directly on the paper as it moves through the press. The paper travels so rapidly through the press that it is not ignited or even discolored. The highly ionized gas flame is a good conductor for static electricity. Ionized air produced by the silent discharge of high frequency high voltage currents is sometimes utilized for the same purpose. In the case of the gas flame the static charges are conducted from the paper through the gas flame to the gas pipe, which is electrically grounded. This method is not applicable, of course, where flammable vapors and dust are present.

Requirements for Non-static Belt Dressing.

If it were possible to use a metallic belt, no static charges would be generated, or if generated they would be neutralized as rapidly as they were formed, since all portions of the belt are electrically connected at all times with the pulley.

In making a study of the formation of static electricity on belts, the theory of applying a dressing or surface coating on a belt that would make the belt a conductor of static electricity was considered. A material may have a resistivity of the order of 10^6 megohms and be a fairly good conductor for static electricity and yet be a good insulator for ordinary electrical uses.

The problem consists in developing a material that can be easily applied to belts; that will have sufficient electrical conductivity to remove or neutralize static electrical charges as rapidly as they are formed; that will resist wear; that will not decrease the coefficient of friction between the belt and the pulley; and that will not be injurious to the belt.

Dressing for Rubber Belts.

Experiments showed that a composition that might be satisfactory for a rubber belt would probably be unsatisfactory for a leather belt.

To produce an electrostatic conducting coating composition, suspensions of a number of electrical-conducting materials of different types in various vehicles were tried. After considerable experimentation it was found that a good grade of spar varnish was a satisfactory vehicle. Powdered aluminum, bronze, copper, graphite, and lamp black were used as the conducting mediums. Various proportions of each of these materials were mixed with spar varnish. Part of each mixture was applied to small pieces of rubber belting 3 inches by 4 inches and allowed to dry. Each sample was tested for electrical conductivity and also to determine the flexibility of the coating. It was found that less of the lamp black was required to produce an electrostatic conducting composition than of the other materials. The large surface area per unit weight of lamp black probably accounts for this difference. About six per cent lamp black represents the minimum quantity that can be used to produce a sufficiently conducting surface coating.

A comparatively simple method was used to determine whether the composition would conduct static electricity. One end of the 3-inch by 4-inch piece of coated belting was placed on one electrode of a static machine, and the other end was grounded. A static voltmeter was connected to the same electrode. When the static machine was operated a voltage was indicated on the static voltmeter if the prepared sample did not conduct. If it did conduct no voltage was indicated.

The Wheatstone bridge was used for measuring resistivity of the samples having comparatively low resistances, and the electrometer method was used for high resistivities. The coefficients of moving and static friction were determined for each sample on a device made in the laboratory.

The compositions which seemed satisfactory from a laboratory standpoint were tried on belts in the mechanical shops of the Department of Agriculture. Numerous difficulties were encountered with the material, such as wearing off the belt too rapidly, sticking to the pulley, or causing the belt to slip on the pulley. Finally, a composition containing 18 per cent lamp black and 82 per cent spar varnish gave the desired results on small scale testing. Before a large scale test in one of the eastern grain elevators was made, the question of the fire hazard which may result from large quantities of flammable vapors given off by the varnish was discussed. It was decided to make the thinner as nonflammable as possible. Orthodichlorbenzene raised the flash point, but the flash point was still too low and the odor was objectionable. Flash points were determined by the open cup method for mixtures of various proportions of Varnish Makers and Painters naphtha and carbon tetrachloride. The flash point of the Varnish Makers and Painters naphtha was 39.5° C. A mixture of 55 per cent Varnish Makers and Painters naphtha and 45 per cent carbon tetrachloride would not flash, and a mixture of 50 per cent Varnish Makers and Painters naphtha and 50 per cent carbon tetrachloride boiled at 75° C. This apparently was a safe mixture from a fire hazard standpoint.

A non-static rubber belt dressing was made by mixing 18 per cent lamp black with a varnish containing 50 per cent Varnish Makers and Painters naphtha and 50 per cent carbon tetrachloride as a thinner. A thinner of this type cannot be used for all varnishes, for the carbon tetrachloride will throw some driers out of solution.

In one test the dressing was applied to a belt driving an air compressor in a grain elevator. All static was removed from this belt, and the manager reported about six months later that no static had been detected on the belt since it had been applied. Previous to the application of this belt dressing it had been impossible to remove all static charges from the belt.

A rubber conveyor belt 850 feet long and 42 inches wide was coated on both sides with the dressing and allowed to dry. The belt was then run at normal speed. Static voltmeter readings showed no static charges on the belt

except at two or three places, where readings of 2000 volts were indicated. The belt was stopped and several places were found where no dressing had been applied. These places were coated and allowed to dry, and when the belt was run again there was no indication of any static charges on the belt. Before the dressing had been applied potentials greater than 10,000 volts were measured on the belt.

Some months after the application of the coating some cracks were observed on the surface, which probably indicated that too much lamp black was used in the dressing.

Other tests were made on threshing machines at one of the factories in the Middle West, where the belts and the machines carried potentials of more than 10,000 volts. After the dressing had been applied no charges were detected either on the belts or the machines. Tests were made in a large flour mill, where the effectiveness of the dressing was further demonstrated. No trace of static was detected after the dressing had been applied.

Leather Belt Dressing.

The composition found most suitable for rubber belts was not satisfactory for leather belts. The drying oils and thinners in the varnish would penetrate the leather and leave a coating of lamp black and resin on the surface. As a result the surface coating did not dry and had a tendency to peel off. The drying oils made the belt stiff and subject to "cracking," and the thinners in some cases dissolved the leather cement used for making the belt.

Lamp black in sufficient quantities to produce conducting surfaces was mixed with a number of commercial belt dressings and applied to belts. All the mixtures tested were found to be unsuitable because they would not stay on the belt.

A number of dressings were made with materials that are considered excellent for belt dressings, such as tallow, neatsfoot oil, and castor oil. Tallow was used as a base for these dressings and was dissolved in pine oil, which was found to be the most suitable solvent. Large quantities of lamp black were required to make the dressings good conductors of static electricity. This in turn made it difficult to apply the dressings to moving belts. It was also discovered that pine oil caused excessive stretching of the belts.

Other tests were made with dressings consisting of various proportions of lamp black, liquid fish glue, glycerine, and water. It was found that the surface formed by these dressings would peel off after the belt was used for some time. This difficulty was overcome by the addition of a sulphonated oil.

Potentials ranging from 1,000 to 40,000 volts were eliminated from a number of belts by a single application of this dressing. After several days of operation the preparation appeared to be satisfactory from every viewpoint, but about a week later some of the belts began to stretch and slip on the pulleys. The coating had lost most of its original "tackiness," due to the absorption by the leather of the penetrating oils and some of the glycerine.

This made the belts flexible, but accompanying the flexibility was the tendency for the belt to stretch. Other dressings were made similar to the above except that other kinds of sulphonated oils were used, and the quantities of sulphonated oil, water, and glycerine were varied. Elongation tests were made to determine the amount of stretch due to the various kinds and quantities of sulphonated oils, also the stretch due to water and glycerine. These tests indicated that sulphonated castor oil produced less stretching than sulphonated cod oil, and that smaller quantities of water and glycerine might be desirable.

It is a well known fact that belts should be treated periodically with water and suitable oils if they are expected to give their best service. If they are not maintained in this manner they become dry and hard and deteriorate rapidly. When the belt dressing is applied to a belt that has not been properly maintained, the belt absorbs the oils and glycerine, and as a result the surface of the belt loses its "tackiness" about one week after the dressing has been applied. This condition may be remedied by making another application of the dressing and continuing to do this until the belt has absorbed enough oil, glycerine and water to make it flexible. This treatment will cause the belt to stretch to some extent. When the dressing is applied to a belt that has been properly maintained by the application of oil and some water, there should be very little additional stretch when the belt dressing is applied.

The dressing that seems to have considerable merit consists of 100 cc. liquid fish glue, 80 cc. glycerine, 100 cc. sulphonated castor oil, 170 cc. water, 82 grams lamp black, and 20 cc. of two per cent ammonium hydroxide. The glue and glycerine are heated 1.5 hours at 110° C. The 2 per cent solution of ammonium hydroxide must not be added until the water has been mixed with the glue and glycerine. This dressing can be easily applied to a belt with a brush while the belt is moving. It is not necessary for the dressing to dry before running the belt.

The proportions given above may not be the best for all conditions. In some cases better results will probably be obtained by increasing the quantities of glue and glycerine.

Summary.

1. Static electricity is a frequent source of ignition for gas and dust explosions.

2. Static electrical charges are generated on power transmission belts by friction of the belt on the pulley, by the separation of the belt from the pulley, and to a less extent by the friction of the atmosphere on the belt. On conveyor belts they are generated in the same way, and in addition by the friction of the conveyed material on the belt. On machinery, static charges can be accounted for by one or more of the following: (1) induction, (2) transmission from other sources, (3) by the friction of the material passing through the machine.

3. Static electricity can be removed from belts and other surfaces by grounding systems, humidifying the air sufficiently, ionizing the air in contact with the belt or other surface by means of a gas flame or by the silent discharge of high frequency and high voltage current. Static electricity can be eliminated by special belt dressings.

4. The requirements for a non-static belt dressing are as follows: (1) It must have sufficient electrical conductivity to remove or neutralize static electrical charges as rapidly as they are formed; (2) it should be of such a nature that it can be easily applied; (3) it should resist wear; (4) it should not decrease the coefficient of friction of the belt on the pulley, and (5) it should not be injurious to the belt.

5. A good rubber belt dressing can be prepared by mixing 18 parts of lamp black with 82 parts of good spar varnish. A smaller quantity of lamp black may prevent most of the cracking which develops after the above dressing is used for several months. The dressing must dry on the belt before running.

A non-flammable thinner for the varnish can be prepared by mixing equal volumes of carbon tetrachloride and Varnish Makers and Painters naphtha.

6. A non-static leather belt dressing which has considerable merit consists of 100 cc. liquid fish glue, 80 cc. glycerine, 100 cc. sulphonated castor oil, 170 cc. water, 82 grams lamp black, and 20 cc. of two per cent ammonium hydroxide. These proportions may not be the best for all conditions. In some cases better results will probably be obtained by increasing the quantities of fish glue and glycerine. It may be easily applied with a brush while the belt is moving. It is not necessary for the dressing to dry before running the belt. If the belt has not been properly maintained this dressing will cause the belt to stretch.

Fire Tests of Hollow Tile.

The results of comprehensive tests to determine the fire-resistance value of hollow clay, load-bearing wall tile, conducted by the U. S. Bureau of Standards under the direction of Mr. S. H. Ingberg (Member N.F.P.A.), in coöperation with the Hollow Building Tile Association, are reported in the January number of the Bureau of Standards *Journal of Research*.*

While hollow clay tile has been used in this country for about 50 years in floor arches, partitions, and as protection for structural members, only during the past 20 years has it been extensively applied for load-bearing purposes in walls. The safe and economical use of this material, as of other masonry materials, requires knowledge of its strength and fire resistance under conditions imposed by severe fires. Fire resistance of walls is rated mainly on ability to keep the temperatures of the side away from the fire low enough so that combustible materials in contact with the wall will not be ignited. Ability

Fig. 1. Small testing furnace, showing wall prepared for test.

*Research Paper No. 37, 334 pages. Reprints obtainable from Superintendent of Documents at 75 cents per copy.

Table 1.—Summary of Ultimate Fire-resistance Periods.

These periods were derived by averaging results from several designs and types of clays the periods from which give a considerable range in values (Fig. 5). For general application the values in the table should be divided by a factor of safety of about 1½ to obtain safe periods that are above the minimums obtaining in the group on which a given value in the table is based.

Design of unit [1]			Nominal wall thickness	Number of units in wall thickness	Number of cells in wall thickness	Sides covered with plaster or stucco	Building members projecting into wall	
Class	Letter in Figure 3	Description					None, or incombustible	Combustible [2]
			Inches				*Hours*	*Hours*
II	C, O, T	3-cell end construction, T-shaped, or double-shell plus three interior cells.	8	1	3	None	2¾	1¼
						One	3¾	1¼
						Both	5	2¼
			12	2	4	None	6	4
						Both	9	5½
			16	2 or 3	5 or 6	None	11	8
						Both	15	10
III	K, P, Q, D, E, S	3-cell side construction, or double-shell plus one or two interior cells.	8	1	3	None	2¼	1
						One	3	1
						Both	4	2
			12	2	4	None	5	3
						Both	7½	4½
			16	2 or 3	5 or 6	None	8½	6½
						Both	12	8
IV	A, B, G, L	2-cell end or side construction.	8	1	2	None	1¾	1
						One	2¾	1
						Both	4	2
			12	1	3	None	3	2¾
						Both	6	4
			12	2	3	None	4	3½
						Both	6½	4½
			16	2 or 3	4	None	6	5½
						Both	9	7
IV. Brick-faced	J, L, M, V, X, Z	End or side construction to line up with brick.	8	2	1	One	4½	2
			12	2	2 or 3	None	6	3½
						One	7	3½
IV. Furred on one side	A, B, L, I	End or side construction to line up with furring	8	1+	2+	One	3¾	1
						Both	5½	2
IV. With air space	H, J, M	3¾-inch 1-cell end or side construction.	10	2	2+ 2″ air space	Both	4	1

[1] [2] See opposite page for footnotes.

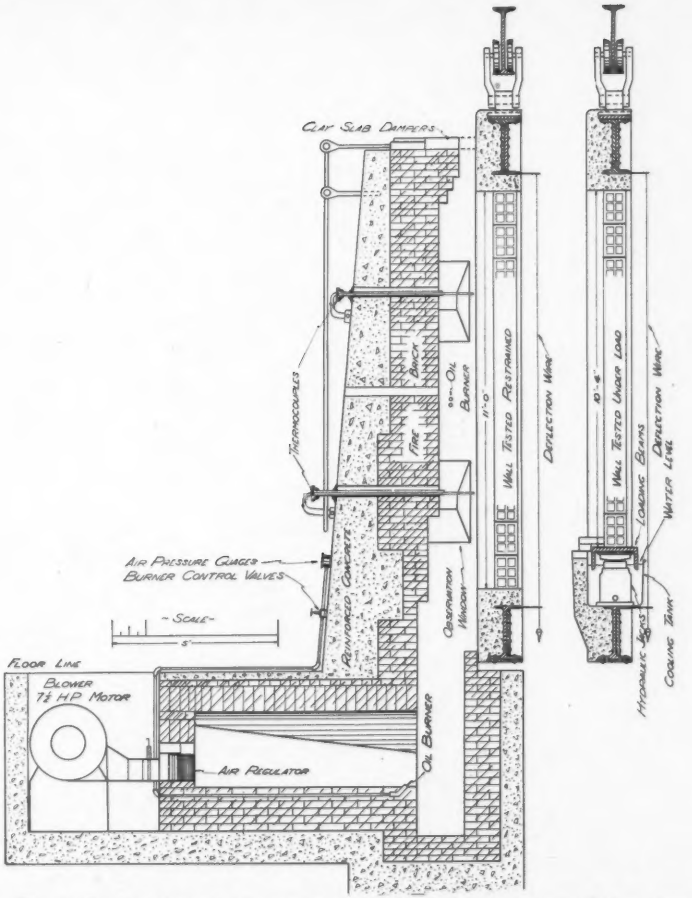


Fig. 2. Section through large testing furnace. The type of containing frame at right was used when load was applied to the walls during the fire test.

---

[1] The designs noted are those of the major units entering into a given construction. The number of cells is the number in an 8-inch thickness taken at right angles to the wall line.

[2] These periods apply only where the hollow space in the wall near the combustible members is unfilled. Where the space is filled solidly with incombustible and fire-resistive materials for the full thickness of the wall and for 4 inches or more above, below and between the members the periods given for incombustible members apply, except that for 8-inch walls unplastered or plastered on one side periods exceeding two hours cannot be taken, and for 8-inch walls plastered on both sides the maximum period to be taken with combustible members is four hours.

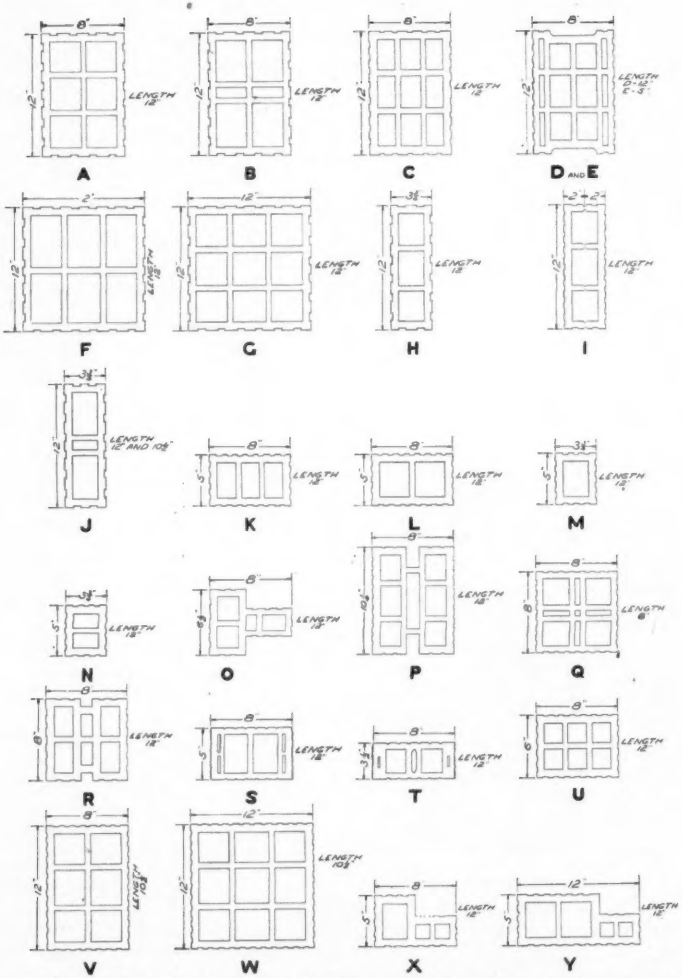


Fig. 3. Designs of hollow tile included in the final series of tests. The letter designations serve as identification of the designs listed in the second column of the summary table of fire resistance periods.

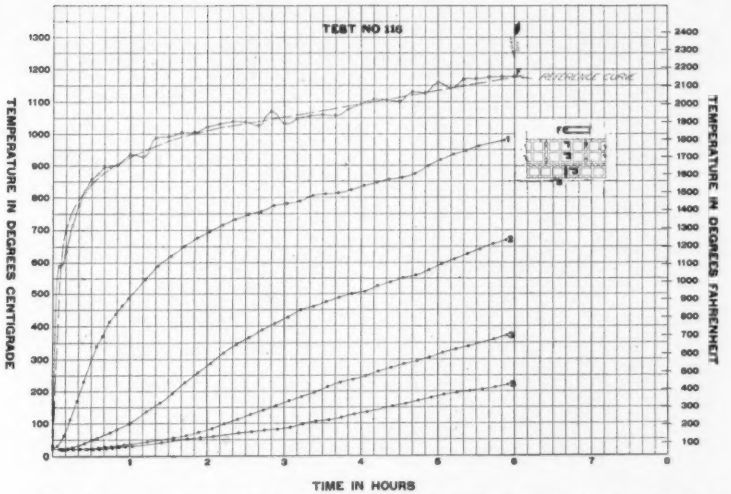


Fig. 4. Furnace and wall temperatures, 2-unit 12-inch unplastered wall of end construction 6-cell and 3-cell surface clay tile (designs B and J of Fig. 3). The fire resistance period as determined by a 250° F. temperature rise under the pad P was reached at 5 hrs. 1 min. This graph shows typical method of showing the temperature data from the tests.

to carry load throughout the fire and to withstand the impact from hose streams are also necessary conditions. The amount of damage incurred and methods of making repairs are also of interest.

The work reported in the paper consists in the main of three series of fire tests of walls built of tile of representative designs and clay materials. The first tests were made on wall sections one foot wide and six feet high that were subjected to fire on one side while under working load, the main object of the tests being to determine how the fire exposure affects the individual tile units. This was found to vary with the type of clay used, hardness of burning and design of the unit, from minor cracking of a few of the units in the specimen, to failure under load a little after two hours.

The second group of tests was with wall specimens four feet wide and four feet high tested exposed to fire on one side, under load (Fig. 1), or restrained within the containing frames, and was made to study the effect of changes in design of the unit, and in the constituents and preparation of the clay. The addition of ground burnt clay (grog) to the raw clay in amounts up to 2 per cent was found to be without effect, but higher percentages increased the fire damage, apparently because of initial shrinkage cracks radiating from the grog particles. Additions of sawdust to the raw clay in amounts up to 15 per cent by volume decreased the tendency to cracking when exposed to

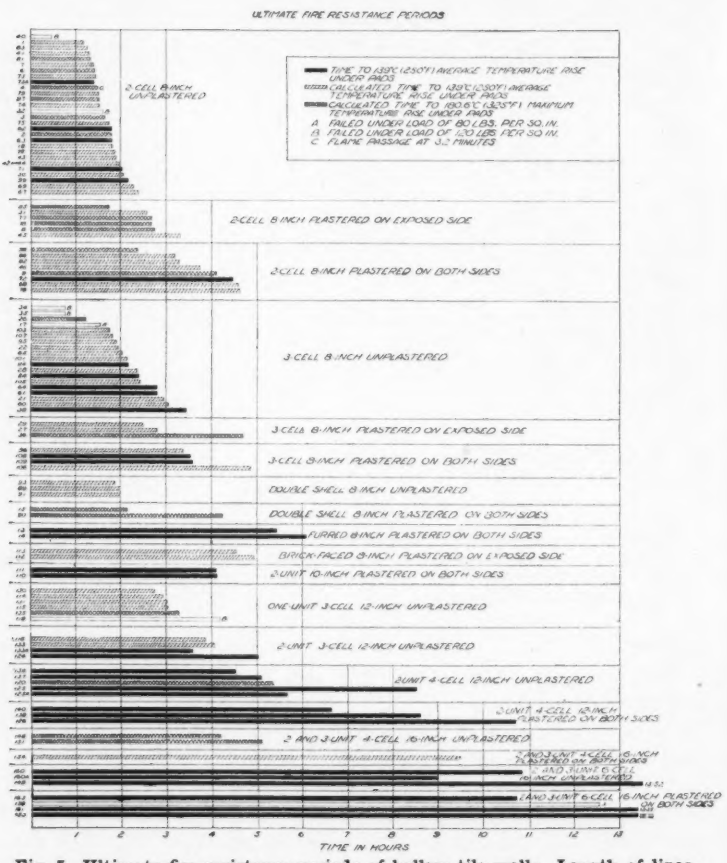

ULTIMATE FIRE RESISTANCE PERIODS
TIME TO 1391°C (2530°F) AVERAGE TEMPERATURE RISE UNDER PADS
CALCULATED TIME TO 1391°C (2530°F) AVERAGE TEMPERATURE RISE UNDER PADS
CALCULATED TIME TO 180.6°C (325°F) MAXIMUM TEMPERATURE RISE UNDER PADS
A FAILED UNDER LOAD OF 80 LBS. PER SQ. IN.
B FAILED UNDER LOAD OF 120 LBS. PER SQ. IN.
C FLAME PASSAGE AT 3.2 MINUTES
2-CELL 8-INCH UNPLASTERED
2-CELL 8-INCH PLASTERED ON EXPOSED SIDE
2-CELL 8-INCH PLASTERED ON BOTH SIDES
3-CELL 8-INCH UNPLASTERED
3-CELL 8-INCH PLASTERED ON EXPOSED SIDE
3-CELL 8-INCH PLASTERED ON BOTH SIDES
DOUBLE SHELL 8-INCH UNPLASTERED
DOUBLE SHELL 8-INCH PLASTERED ON BOTH SIDES
FURRED 8-INCH PLASTERED ON BOTH SIDES
BRICK-FACED 8-INCH PLASTERED ON EXPOSED SIDE
2-UNIT 10-INCH PLASTERED ON BOTH SIDES
ONE UNIT 3-CELL 12-INCH UNPLASTERED
2-UNIT 3-CELL 12-INCH UNPLASTERED
2-UNIT 4-CELL 12-INCH UNPLASTERED
2-UNIT 4-CELL 12-INCH PLASTERED ON BOTH SIDES
2 AND 3-UNIT 4-CELL 16-INCH UNPLASTERED
2 AND 3-UNIT 4-CELL 16-INCH PLASTERED ON BOTH SIDES
2 AND 3-UNIT 6-CELL 16-INCH UNPLASTERED
2 AND 3-UNIT 6-CELL 16-INCH PLASTERED ON BOTH SIDES
1 2 3 4 5 6 7 8 9 10 11 12 13
TIME IN HOURS

Fig. 5. Ultimate fire resistance periods of hollow tile walls. Length of lines indicates periods. Note large range within each group.

fire without seriously decreasing the normal strength of the tile. Fine grinding and greater amount of pugging of the raw clay increased the strength of the tile and consequently its load-carrying ability when exposed to fire.

Of modifications in the design of the unit, one with double outside shells improved the fire resistance for all but very dense tile in confining the cracking mainly to an outer thin shell. Increased shell thickness was also found to decrease the fire effects, as also fillets of up to one-fourth inch radius at the junctions of shells and webs.

The final series consisted of 167 fire endurance tests and four fire and water tests of typical wall constructions, 71 of which were made with walls

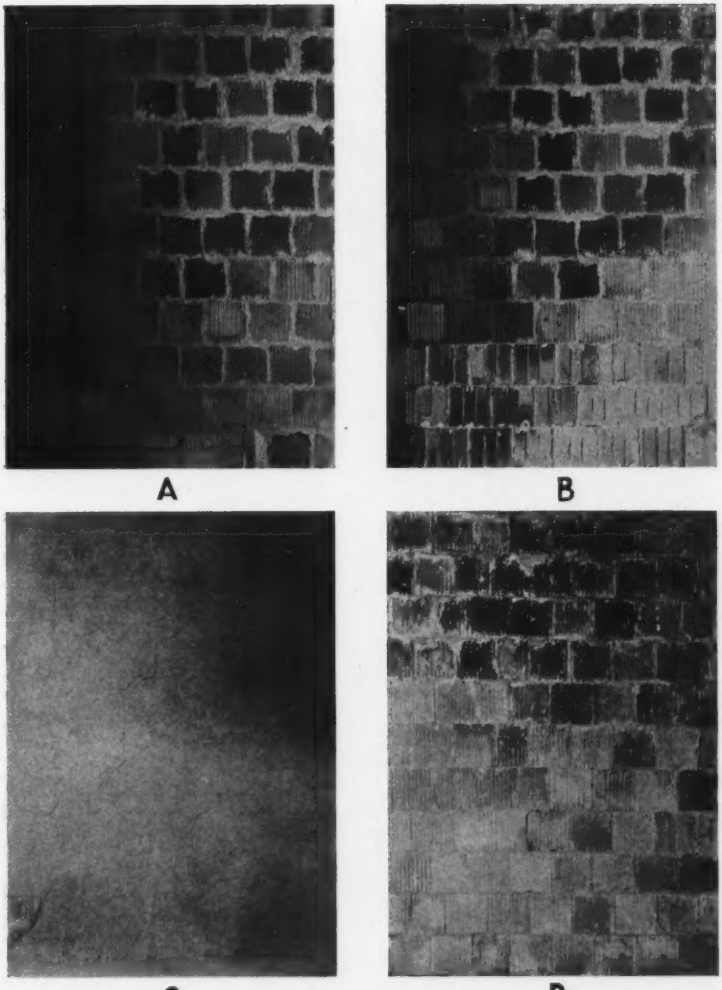


Fig. 6. A. Exposed side of 8-inch wall of hard-burning fire-clay tile of the double-shell design (D, Fig. 3) after fire exposure of six hours. B. Same after removal of some of the loosened outer shells. C. Exposed side of a similar wall covered with gypsum plaster, after fire exposure of six hours. D. Same after removal of plaster. Plaster that stays in place during the fire exposure increases the fire resistance periods and also decreases the fire damage.

between 10 and 11 feet high and 8 to 16 feet wide (Fig. 2). The thickness ranged from 8 to 16 inches, and plaster, stucco, or brick facing was applied on a number of the walls. The walls were subjected to constant applied loads of 70 to 120 lbs. per sq. in. during the fire test, were restrained within the containing frames, or were tested unrestrained, the latter condition being representative of walls in low buildings or the upper story walls of higher buildings. The results are summarized as fire-resistance periods, which are determined by the time the walls sustained load under fire exposure (corresponding in severity to the standard furnace test) and prevented the average temperature rise on the unexposed side from exceeding 139° C. (250° F.), or the maximum rise at any point where temperature measurements are taken from exceeding 180.6° C. (325° F.). Freedom from cracks or openings large enough to transmit flame or ignite combustible materials is also required both in fire-endurance tests and fire and water tests.

The final grouping of test results (Table 1) is in three classes, determined by the design of the tile. Fire-resistance periods are given for 8, 12 and 16-inch walls in each class, the values varying with the thickness and design from $1\frac{3}{4}$ to 11 hours for unplastered walls and from 4 to 15 hours for walls plastered on both sides. Periods are also given for walls assumed to have combustible members projecting into them four inches from the unexposed side, this being determined by the time required for temperatures high enough to ignite wood to obtain at a given depth in the wall. Fire-resistance periods for this condition ranged from one hour with 8-inch unplastered walls to 10 hours with 16-inch plastered walls built of tile of the designs giving the highest results.

Gypsum and Portland cement plasters applied on one or both sides of the wall constructions not only increased their fire-resistance periods, but that on the side exposed to fire also appreciably decreased the fire effects on individual units and the construction generally. Where applied on split furring tile, plaster was found to prevent all fire damage to the load-bearing tile in fire tests lasting as long as six hours.

Knoxville Gravity Tank Collapse.

Photographs from Tennessee Inspection Bureau (Member N.F.P.A.).

This 35,000-gallon elevated tank at the Knoxville Knitting Mills Plant No. 1 collapsed on March 15, 1929, at 4 A.M. A large pit had been excavated between the supporting columns for the purpose of constructing a concrete pool for flood waters. The banks of the pit had not been shored; the bank caved in and the column foundations were left without support.

A close-up of the excavation and débris.

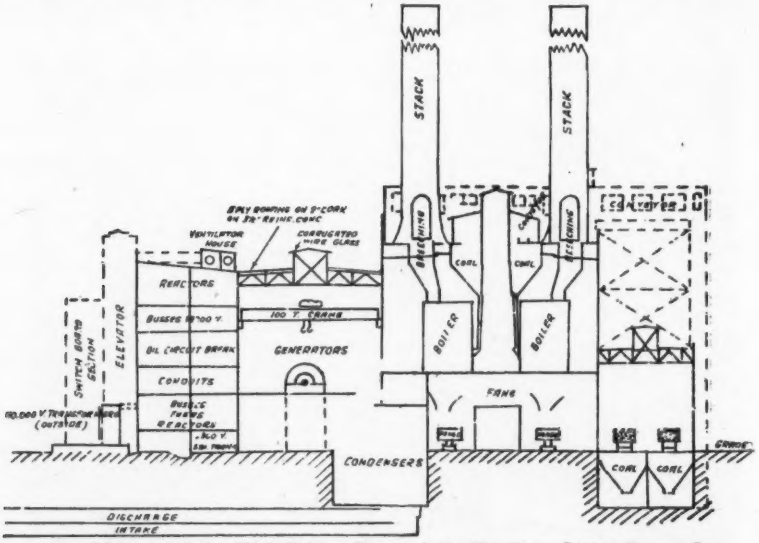
Northern States Power Plant Fire.

Report by James S. Mahan (Member N.F.P.A.),
Western Actuarial Bureau.

The rupture of a 32,000 KW. turbine generator and ensuing fire on January 3, 1928, caused an aggregate loss of $420,000 in the High Bridge Station of the Northern States Power Company at St. Paul. This fire is of particular interest because the building, with the exception of the bare steel roof trusses, is of fire-resistive construction. The design of the station is thoroughly modern in every respect, and with the exception of oil in the enclosed lubricating system there was practically nothing to burn in the generator room. Because of pending litigation it has been impossible to release a complete report on this fire previously. Although it is now over a year since the fire, so many interesting features are involved that it is felt that a full report should be published.

Construction and Occupancy.

The station, erected in 1924, is of fire-resistive construction, the general arrangement and character of the building being indicated by the diagram, Figure 1, and the photograph, Figure 2, which shows the interior of the generator room prior to the fire. As the fire did not extend beyond the generator



1. Diagram of the High Bridge Plant of the Northern States Power Company, St. Paul.

2. Interior of the generator room prior to the fire. The machine in the foreground is unit No. 2, which failed. Note the bare roof trusses and the monitor.

room, further description will be limited to this portion of the building, which was reasonably well cut off from other portions of the structure in accordance with the usual practice in the design of electrical power stations.

The roof construction consisted of a three-inch reinforced concrete slab laid upon bare steel trusses and purlins. Running the length of the roof there was a six-foot monitor glazed with wired glass. Roof insulation for the purpose of decreasing condensation was provided in the form of two-inch cork blocks cemented in place, covered with five-ply composition roofing. Subsequent to the erection of the station it was found necessary to provide against condensation in the monitor, and for this purpose an outer structure of frame construction with thin glass was built over the outside of the monitor. Through the center of the monitor ran a fifteen-inch I-beam, supported at approximately twenty feet intervals on the main roof trusses. This I-beam is approximately forty-two feet above the tops of the turbines.

The turbines shown in Figure 2 were 30,000 kilowatts, 14,000 volts, 1800 R.P.M., driven by seventeen stage turbines, as originally purchased, when this photograph was taken. It has been the practice in this station to dismantle these units once a year for thorough cleaning and mechanical inspection. At the time of the 1927 inspection generator No. 2 (shown in the foreground of Figure 2) was rewound and its capacity increased from 30,000 to

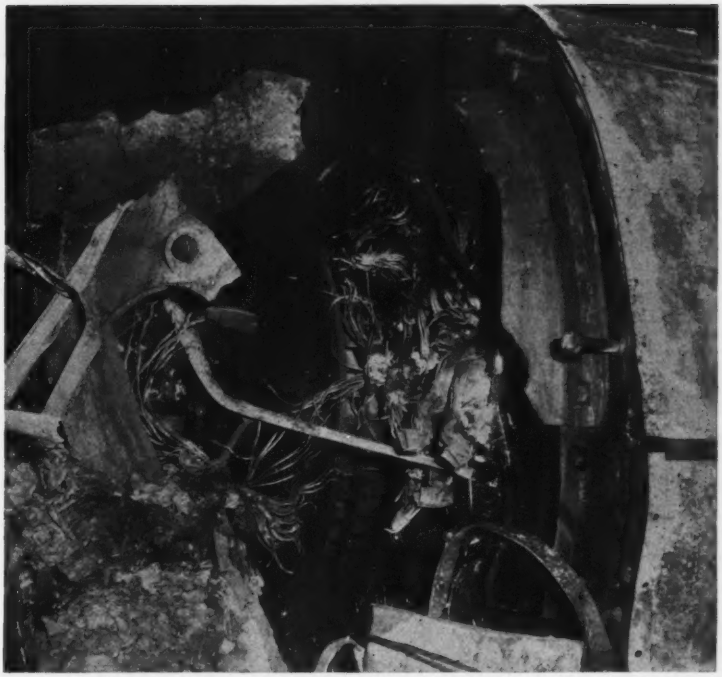
3. The steam end of machine No. 2 after the fire. Compare this with Figure 1 and note the smoke blackened walls.

32,000 kilowatts. At this time a new large forged non-magnetic steel retaining ring was placed on each end of the generator rotor. This unit was put back into service in the later part of September, 1927, and had given good service up to the time of the rupture on January 3, 1928. The oil circuit breakers, reactors, etc., were located in sections devoted exclusively to this occupancy and were not exposed to any of the fire in the generator room. High tension transformers were located outside the building.

The boiler section contained eight 1800 H.P. boilers. For each turbo-generator there was an oil system containing between 2500 and 3000 gallons of lubricating oil, which was circulated through the machine by means of a pressure pump. Of this amount about 1700 gallons are always in the filter and are conveyed from the filter to the main tank by an independent pump; thus about 1000 gallons of oil may be discharged under direct pressure to each unit.

Story of the Fire.

Turbo-generator No. 2 had been shut down over the New Year's holiday and had been started again at 5 A.M. on Tuesday, January 3, 1928. Rupture of the generator retaining ring on the end next to the steam end of the unit occurred at 2:29 P.M. without any preliminary misbehavior of the unit. The normal rating of this machine is 1650 amperes, but the meter chart showed only 1300 amperes at the time of the rupture, which is conclusive evidence that there had been no overload. The generators were protected by differential



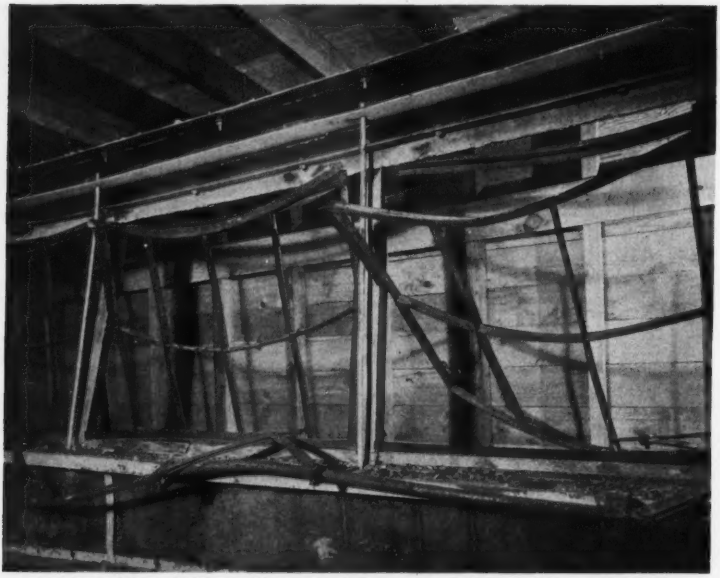
4. A close-up of the generator end of machine No. 2, showing the character of the damage.

relays. The operation of these was evidently instantaneous, as there was no indication of any fluctuation shown on the recording voltmeter chart on the station bus.

Both the high pressure oil pipe and the six-inch oil return pipe of the lubricating system of this unit were broken. The oil ignited and caused an intense fire. The intensity of this fire is indicated by the fact that face brick were badly spalled on a portion of the building wall about 4 x 8 feet, approximately twenty-eight feet away horizontally from the broken oil line.

The roof monitor was quickly involved. The wired glass failed and the plain glass of the exterior structure was broken out, the burning wooden framing falling down into the station. This necessitated shutting down turbine No. 1 for about a half hour period.

The station operating force had been apparently well trained for emergencies and handled the situation very creditably. With the turbines out of service the steam consumption was stopped, also the electric feed water pumps. Prompt action was necessary to avoid the danger of boiler explosions. Auxiliary steam driven feed water pumps were started promptly and no trouble with the boilers resulted.



5. A portion of the monitor, showing the warped steel frames and distorted control rods. The wooden construction shown in this picture is a temporary shelter erected after the fire.

In view of the character and extent of this fire, the method of extinguishment was remarkable. It was handled entirely with first aid fire appliances. The station was equipped with fifty-four one-quart carbon tetrachloride extinguishers, six one-gallon tetrachloride extinguishers, and eleven two and one-half gallon soda acid extinguishers. The employees used this first aid equipment and had the fire under control by the time of the arrival of the fire department. No water was used on this fire. It was handled entirely by soda acid and carbon tetrachloride extinguishers. Both the city fire department and salvage corps did very creditable work.

Damage.

The character of the damage is indicated by photographs, Figures 3, 4 and 5. Figures 3 and 4 show the two ends of machine No. 2 and show how the white brickwork was blackened (see Figure 2) by the smoke. Figure 5 is a close-up of a portion of the monitor, showing the warped and distorted steel frame which originally held the wired glass.

The entire monitor was more or less damaged, with all the thin glass in the temporary exterior structure cracked and part of this burned away completely. The two-inch cork laid on top to prevent condensation was damaged to a considerable extent at some portions. The wired glass was destroyed for approximately one hundred feet of the monitor, with the metal frames and controlling rods for operating the sash damaged beyond repair. The fifteen-

inch I-beam through the center of the monitor was buckled approximately three inches. The angle irons along the lower inside monitor were thrown out of line about six or seven inches at the point of worst deflection. The roof trusses immediately above the damaged turbine were more or less warped.

On the floor of the station the walls, pipe covering, guard rails, glass, electric light fixtures, etc., were damaged either by the fire or by the flying parts of the broken machine.

The one hundred-ton electric crane was fortunately at the opposite end of the station (background of Figure 2) and was not damaged in any way. If this crane had been damaged or destroyed there would have been a material additional delay in removing and replacing the damaged unit.

All visible damage to the generator was on the end toward the steam unit. The end bell was broken into a number of pieces, as indicated in Figure 4. The retaining ring was broken into thirty or more pieces. The ends of all the coils in stator and rotor were either severed or crushed. The material found wedged between the stator and rotor indicates that the machine had stopped almost instantly. The frame and base of the generator were cracked. On the steam end the base of the machine was cracked and there was evidence of strain and friction on the bucket wheels of the turbine, but as far as could be determined no blades were torn out. After removing the housing of the coupling between the turbine and generator it was found that all the bolts fastening the two parts had been completely sheared.

There was no evidence on the collector rings of the generator of any arcing or flash-over, and the consensus of opinion of all those who studied the rupture was that the initial cause was a mechanical failure, with the broken oil lines the chief factor in the fire which followed.

The loss to the machine is estimated at $360,000, and to the building at $60,000.

Conclusions.

The circumstances of this fire lead to the following observations and conclusions:

1. Measures should be taken to reduce to a minimum the amount of lubricating oil subject to pressure.
2. Considerable damage may be expected from a fire even in an incombustible power station of modern construction.
3. Fires of considerable size may be handled in power stations with ordinary first aid fire appliances without necessitating the use of hose.
4. Combustible additions, even located above a roof, may be expected to ignite in case of an interior fire, thereby adding to the extent of the damage to the building.
5. The value of highly trained and alert personnel was conclusively shown in this case, which was handled with a minimum of financial loss and inconvenience to all concerned.

Garage Fire Record.

The registration of motor vehicles in the United States reached a peak of 23,127,315 in 1927, the latest year for which complete figures are available. Production figures of motor car and truck manufacturers for that year and 1928 show a steady increase in output and would seem to indicate a continued upward swing in the registration curve. From 1917 to 1927 the increase in registration was 18,143,975, or 363%. The increase in annual production for the same period was 1,699,722, or 91.0%.

Unfortunately there are no satisfactory national statistics on garage construction, but motor cars are too valuable to be left in the open exposed to weather, and it is reasonable to assume that garage facilities have increased in proportion to the automobiles. Fire experience and municipal legislation have been responsible for great improvements in modern garages, but there still remain a vast number presenting hazardous conditions, structurally and in their contents, from a fire standpoint.

Statistics compiled by the National Board of Fire Underwriters (Member N.F.P.A.) a few years ago placed the number of public garages in the United States in 1924 at 49,156. From January 1, 1918, to December 31, 1922, there were tabulated fire losses in public garages amounting to $19,677,593 on buildings, equipment and contents such as would be found in this class of occupancy. This loss grew out of 11,519 claims for insurance. With an average number of claims per annum of 2304, it will be seen that out of every twenty-one garages one suffers more or less severely from fire every year; or, to put it another way, one public garage is, on the average, visited by flames every three hours—a high ratio of burning even in America.

The files of the Department of Fire Record of the National Fire Protection Association contain reports on approximately fifteen hundred garage fires, including buildings of all classes used for garage or repair shop purposes, but excluding automobile paint shops and filling stations. The first garage fire record appeared in the QUARTERLY for July, 1911, and was based on 126 fires which had been filed up to that time. In 1920 another fire record was compiled covering 513 fires occurring between 1915 and 1920. The present fire record brings it up to date.

In making up the accompanying data, reports covering only the period from January 1, 1921 to December 31, 1928, have been used, as the development of the automobile and changes in garage construction and operation have been such that fires prior to 1921 may not represent present day conditions. A total of 673 fires have been analyzed, and this analysis has been supple-

mented by data taken from a number of State Fire Marshals' reports and reports of Insurance Fire Patrols.

The record is by no means complete and does not include many of the small fires which are occurring daily in garage properties. Insurance inspection bureau reports are the source of data on the majority of garage fires, supplemented by reports based on newspaper accounts which have been verified through the coöperation of N.F.P.A. members.

In view of the character of the original data, which include the larger and more important fires but not a fair proportion of the smaller fires, this record may not be completely representative. The record, however, includes a sufficiently broad selection of the important garage fires so that there can be no question as to the validity of conclusions drawn in the tables here.

That garage fires have increased in the past few years is borne out by the table shown below, indicating the number of fires occurring in garages for the period 1919-1927 inclusive in the State of Massachusetts, New York City, Philadelphia, and Baltimore. It also indicates the relative frequency of such fires. In compiling these data it was interesting to note that of a total of 4963 fires in garages in New York City, 3098, or 62.4%, had their origin in automobiles stored in the garages. Fires so originating ranged from a low figure of 167 in 1919 to a high of 550 in 1926.

Number of Fires in Garages—Years 1919-1927 Inclusive.

Year	State of Massachusetts	New York City	Philadelphia	Baltimore
1919	134	305	49	71
1920	147	403	62	93
1921	192	529	39	86
1922	207	421	53	63
1923	195	459	106	70
1924	238	621	94	73
1925	262	665	108	94
1926	294	843	143	88
1927	242	717	117	84
Total	1911	4963	771	722

These figures include all garage fires—both in public and private garages.

The increase in garage fires shown by the preceding table may well be viewed with some concern, for it would seem that the presence of considerable quantities of gasoline and the apparent lack of proper safeguards thrown about it have in a measure offset the recent tendency toward higher standards of construction and protection.

It is obvious that, with the rapid increase in garages, there is a tendency toward higher standards. This is particularly apparent in the matter of construction, proper safeguarding of hazards, and also the requirement as to sprinkler protection under certain conditions.

The more progressive states and municipalities have been active in the past few years in the enactment of legislation requiring in the larger garages

such safeguards as fire-resistive construction, fire walls when a large area is involved, cut-off sections for boiler room and repair and service departments, good housekeeping, protection against exposure, and adequate interior fire protection.

That the values involved in garages are large is obvious, as is indicated by the following figures furnished by the U. S. Department of Commerce relative to building permits issued by 292 cities in 1927.

	Total No. Buildings	Proposed Cost
Public Garages	4,166	$74,124,000
Private Garages	180,174	64,944,000
Total	184,340	$139,068,000

Similar figures for factories and workshops show 4139 permits with a proposed cost of $139,223,000, which will give a fair comparison of the relative importance of garage construction as a building factor.

Loss Statistics—Garage Fire Record.

	State of Massachusetts		State of Iowa		City of Philadelphia	
Year	Fires	Loss	Fires	Loss	Fires	Loss
1919	134	$143,511	40	$123,520	49	$104,624
1920	147	229,978	71	422,398	62	251,822
1921	192	337,987	69	317,919	39	77,749
1922	207	339,954	48	278,126	53	95,314
1923	195	254,582	39	148,370	106	197,031
1924	238	242,756	91	219,185	94	70,072
1925	262	368,064	66	215,672	108	133,201
1926	294	257,313	49	118,963	143	119,632
1927	242	180,076	51	80,392	117	70,375
Total	1911	$2,354,221	524	$1,924,545	771	$1,119,820
Average Loss per Fire.		$1,225		$3,770		$1,450

The above figures include both public and private garages. The greater average loss per fire in the State of Iowa may be due to a larger proportion of country garage fires, occurring in small communities with meager fire fighting facilities or beyond organized fire protection.

Considering these loss figures from the viewpoint of distribution between buildings and contents, we find that in the States of Massachusetts and Iowa the loss on contents amounts to approximately 60% of the total loss, while in a single city, Philadelphia, it is but 48%. The reason for this is not entirely apparent, except it would seem that better housekeeping, greater safeguards and fire-resistive construction would be more likely to be found in a large metropolitan city than in either of the states at large.

Distribution of Losses.

	Massachusetts		Iowa		Philadelphia	
	Total	Per Cent	Total	Per Cent	Total	Per Cent
Loss Buildings.	$950,093	40.2	$720,068	37.6	$572,614	51.4
Loss Contents..	1,404,128	59.8	1,204,407	62.4	547,206	48.6
Total Loss...	$2,354,221	100.0	$1,924,525	100.0	$1,119,820	100.0

Pacific & Atlantic.

Masonry walls do not make a building "fireproof." Garage fire in Chicago, Illinois, February 2, 1926. Exploding tanks of more than thirty automobiles made fire fighting difficult.

Other loss data are available for shorter periods from the State of Kansas and Province of British Columbia. Kansas, in the three-year period 1926 to 1928 inclusive, had 508 fires in garages, involving a total loss of $537,183—an average loss per fire of $1057. The statistics for British Columbia cover four years, from 1924 to 1927 inclusive, and show 131 fires, involving a total loss of $205,096, making an average loss per fire of $1565. These fires seem to bear out the value of the average loss per fire as a satisfactory index for determining relative losses for this type of occupancy.

Analysis of Loss—Garages.

N.F.P.A. Fire Records, 1921-1928.

	Sprinklered		Unsprinklered			
	Fires	Per Cent	Fires	Per Cent	Total	Per Cent
Small Loss (Under $1000)....	261	89.0	101	26.6	362	54.8
Moderate Loss ($1000-$5000).	16	5.5	25	6.6	41	6.1
Large Loss (Over $5000).....	10	3.4	241	63.4	251	37.3
No Data.....	6	2.1	13	3.4	19	2.8
Total.....	293	100.0	380	100.0	673	100.0

The next tables show the causes of garage fires. The first three have been prepared from N.F.P.A. records, while the other tables give similar figures for the State of Massachusetts, the City of Philadelphia, and the State of Kansas. These data from separate sources, compiled on different bases, appear to agree as to the relative importance of major causes.

In the main table of causes, made up from N.F.P.A. records, the data have been classified in such a way as to bring out the gasoline vapor hazard, which is of primary consideration in garage occupancies. In the two supplementary tables, fires in which gasoline was the contributory cause and fires in which electricity was a major factor have been segregated.

Garage Fire Causes.

N.F.P.A. Fire Records, 1921-1928.

	No. Fires		Per Cent of Known Causes
Special Hazard Causes			
Automobile Causes:			
Electrical Causes	80		14.1
Back-fire or Exhaust	31		5.5
Miscellaneous	29		5.1
Total Automobile Causes		140	24.7
Garage Causes:			
Cleaning with Gasoline	46		8.1
Ignition of Flammable Liquids or Vapors	46		8.1
Mechanics' Torches	32		5.6
Gasoline Storage or Filling	30		5.3
Oily Material	27		4.8
Welding	8		1.4
Vulcanizing	7		1.2
Battery Charging	4		.7
Emery Wheel	2		.4
Miscellaneous	8		1.4
Total Garage Causes		210	37.0
Total Special Hazard Causes		350	61.7
Common Causes			
Heating	72		12.7
Smoking—Matches	54		9.5
Electrical Causes	47		8.3
Rubbish and Sweepings	14		2.5
Miscellaneous Known Causes	10		1.8
Total Common Causes		197	34.8
Incendiary		13	2.3
Exposure		6	1.2
Total Known Causes		566	100.0
Unknown		107	
Total Number of Fires		673	

Gasoline as a Contributory Fire Cause.

	No. Fires
Cleaning with Gasoline	45
Gasoline Ignited During Filling Operation	24
Gasoline Spilled on Floor Ignited	17
Gasoline Vapor Ignited from Electrical Causes	16
Gasoline Vapor in Tanks of Cars Ignited by Mechanics' Torch or Electric Drill	14
Gasoline in Open Containers	9
Gasoline or Vapor Ignited by Open Flame	8
Overflow of Gasoline	7
Gasoline Improperly Drained	5
Gasoline Ignited—No Specific Cause	4
Gasoline Put in Fuel Oil Tank by Mistake	1
Total	150

Electricity as a Cause of Fire in Garages.

	No. Fires
Defective Wiring	23
Short Circuit of Extension Cord Ignited Gasoline	13
Short Circuit in Wiring	12
Overloading Electric Motor	7
Spark from Electric Drill or Motor	7
Spark from Broken Electric Light Bulb	6
Short Circuit in Motor	4
Electric Starter of Gasoline Pump	2
Short Circuit of Extension Cord Ignited Paint Remover	1
Total	75

Causes of Garage Fires, 1919-1927.

State of Massachusetts.

	No. Fires
Electrical Causes	326
Smoking—Matches	318
Ignition of Volatile Flammable Liquids	202
Spontaneous Ignition	92
Sparks from Bonfire, Brush or Grass Fire	46
Overheated Heating Equipment	42
Sparks from Chimney or Locomotive	23
Heating or Lighting Equipment Igniting Merchandise	21
Hot Ashes	19
Lamp, Lantern or Stove Upset or Exploded	18
Malicious Mischief	16
Defective Chimney or Flue	14
Incendiary	13
Defective Oil Burner	12
Fireworks	12
Lightning	11
Mechanics' Torches	10
Friction	10
Defective Heating Equipment	8
Sparks from Forge, Furnace or Stove	6
Miscellaneous Known Causes	25
Unknown—Suspicious	7
Unknown	66
Not Stated (1921-1922-1923 causes not classified)	594
Total	1911

City of Philadelphia.

	No. Fires
Smoking—Matches	154
Electrical Causes	76
Gasoline Motors (Automobiles)	47
Sparks from Chimneys	45
Rubbish or Sweepings	42
Stoves, Furnaces, and Their Flues	32
Heaters	22
Fuel Oil Burners	18
Hot Ashes	15
Explosion of Gasoline	15
Gasoline Torch or Lantern	13
Illicit Stills	12
Spontaneous Ignition	9
Lamp, Lantern or Oil Stove	8
Friction	6
Incendiary	3
Miscellaneous Known Causes	35
Unknown	220
Total	771

International.

When this Seattle, Washington, building burst into flames it contained 235 automobiles. Something went wrong in the basement and started this $2,000,000 bonfire in the center of the automobile district. Automobile storage in quantity always means a high hazard to the building concerned and to adjoining property.

Garage Fire Record, State of Kansas, 1926 to 1928 Inclusive.

Cause	No. Fires	Loss
Electrical Causes	85	$130,255
Rubbish and Sweepings	55	7,135
Smoking—Matches	38	9,353
Exposure	27	97,984
Gasoline and Kerosene	20	20,861
Stoves, Furnaces, etc.	20	7,852
Spontaneous Ignition	16	3,580
Open Fires and Lights	13	4,499
Incendiary	8	8,395
Sparks on Roofs	7	626
Fireworks	7	490
Lightning (not rodded)	6	15,866
Explosions (other than petroleum products)	6	43,230
Gas	4	10,625
Hot Ashes	3	135
Sparks from Machinery	3	280
Hot Grease, Tar, etc.	2	35
Overheated Chimney or Flue	2	50
Miscellaneous Known Causes	37	16,897
Unknown	147	159,035
Total	508	$537,183

Fire Engineering.

An oil lamp suspended from the rear end of a truck is believed to have been the cause of a fire which destroyed a garage on the East Side of New York City on Nov. 1, 1928. Two men sleeping in a parked truck were burned to death. The garage, with about two hundred cars, was destroyed.

The foregoing tables of fire causes indicate clearly that garages differ from other occupancies in that special hazard causes are a greater factor than common causes in the fire record. In the present study they are responsible for approximately 62% of the fires for which the cause is reasonably well known. This compares with 59% in the previous fire record for this occupancy (QUARTERLY, Vol. 14, No. 2).

Automobile Causes.

Electrical causes lead the list of this class of fire causes with eighty fires. "Short circuit" as an automobile fire cause is always open to question, and it is possible that in a number of fires in this record to which this cause was assigned there may be some doubt as to whether or not it was the actual cause. This is particularly true of fires which originated in automobiles in garages at a time when no one was present. An analysis of fires attributed to electrical causes is as follows:

	No. Fires
Short circuit in automobile wiring	69
Started in or around ignition system	6
Short circuit ignited lacquer on car	2
Spark from defective wire ignited leaking gasoline tank	1
Spark caused by tool dropped across battery terminals ignited paint remover on car	1
Recharging electric truck	1

The number of fires from back-fire or exhaust shows a material reduction from the data compiled in 1920. In the former fire record 126 fires were

attributed to this cause, while the present record indicates but 31. Of these, 23 ignited the car of origin, while the remaining eight ignited gasoline or vapor incidental to cleaning or on the floor.

Miscellaneous known causes account for the remainder of the fires classified as automobile causes, and the following analysis shows their origin:

	No. Fires
Started around car or truck (exact cause unknown)	23
Spontaneous ignition of oily material in car	2
Gasoline or fumes ignited while draining tank	2
Car dropped down elevator well	1
Leak in gasoline line	1

Garage Causes.

Chief among garage causes are cleaning with gasoline and ignition of flammable liquids or vapors from sundry causes. These two classifications are closely allied, in that gasoline is the main contributory cause. There is, however, sufficient differentiation to warrant separation into two classes, and the following analyses will serve to indicate the division.

Cleaning with Gasoline.	No. Fires
Spark from ignition system ignited gasoline vapor while motor was being washed	11
Gasoline used for washing ignited by cigarette or match	10
Gasoline used for cleaning ignited by unknown cause	5
Washing parts in gasoline. Vapor ignited by open flame	4
Gasoline used for cleaning spilled and ignited by short circuit in extension cord	3
Back-fire ignited gasoline vapor in motor, which had just been cleaned	3
Steel wool brush in contact with battery caused spark which ignited can of gasoline	2
Hot motor ignited gasoline vapor while cleaning	2
Spray gun nozzle came in contact with ignition wires	2
Mixture of distillate and water in soap solution tank boiled over and ignited from open flame of heater	1
Gasoline on surface of tank of cleaning solution ignited when tank boiled over	1
Cleaning floor with gasoline. Vapor ignited by open flame	1
Static spark ignited gasoline vapor while cleaning	1

Ignition of Flammable Liquids or Vapors.	No. Fires
Short circuit of electric extension cord ignited gasoline or vapor	10
Gasoline vapor ignited by open flame	8
Spark from electric drill	6
Spark from broken electric light bulb ignited gasoline or vapor	6
Gasoline ignited—no specific cause	4
Spark from friction	2
Short circuit of electric extension cord ignited paint remover	2
Spark from emery wheel	1
Spark from electric motor	1
Spark from hobnail shoe in contact with concrete floor ignited gasoline vapor	1

International.

What can happen when fire starts in a large frame garage. Bus garage and service station of Yellowstone Park Transportation Co. at Mammouth Hot Springs, Wyoming.

Hot part plunged into pail of gasoline mistaken for water	1
Kerosene spilled in coal bin flashed when coal was shoveled into heater	1
Cleaning solution ignited	1
Oil put on stove to heat. Solder on can melted and oil flowed on to stove and ignited	1
Sparks from pulling metal drip pan ignited transmission oil and gas	1

Mechanics' torches as a fire cause also show a marked increase from the former fire record. These fires are closely related to fires attributed to welding and hence the two classifications may be analyzed as a group.

Mechanics' Torches.

	No. Fires
Explosion of gasoline torch	6
Flame of oxy-acetylene torch set fire to work bench	4
Gasoline or acetylene torch ignited open pan of gasoline	4
Blow torch—no data	4
Gasoline fumes in tank of car ignited by soldering torch	3
Acetylene torch being used to burn carbon. Sparks ignited gas and oil	2
Explosion of acetylene torch	2
Gasoline torch tipped over and ignited gasoline	2
Explosion occurred when acetylene torch was applied to battery	1
Back-fire of gasoline torch	1
Oxy-acetylene torch—no data	1
Gas torch set fire to gasoline floating on water in testing tank	1
Torch ignited automobile top	1

Welding.

	No. Fires
Gasoline vapor in automobile tank ignited by flame of welding torch during repairs	5
Tube from acetylene tank blew off and acetylene ignited	2
Clothing of mechanic ignited by welding torch. In confusion pail of gasoline was tipped over and ignited from torch	1
Welding torch suddenly burst into flame while being used	1

Always a danger around garages, and one which is particularly acute during cold weather, is the possibility of developing static electricity while engaged in filling the tank of an automobile. Instances abound where such ignition has resulted not only in heavy explosion and fire damage but has occasioned loss of life. Likewise, the hazard of smoking or carrying a lighted lantern while filling a gasoline tank should be sufficiently obvious.

The greater portion of the fires classified under gasoline storage and filling were due to carelessness and were strictly preventable.

Gasoline Storage and Filling.

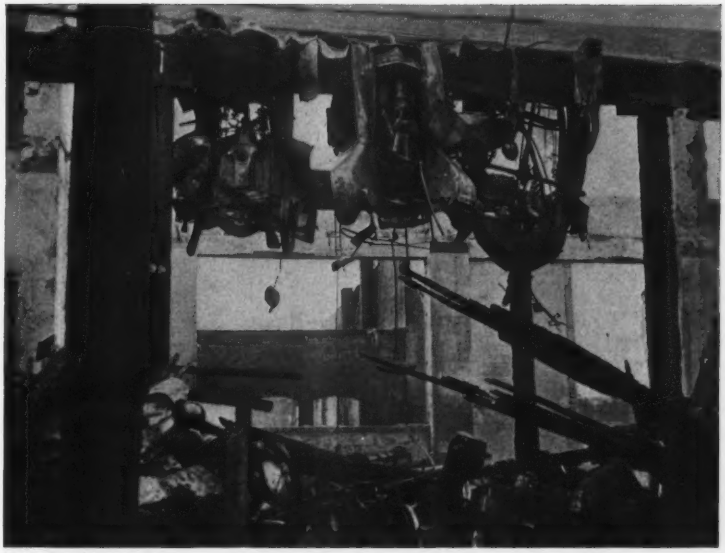
	No. Fires
Static spark	6
Vapor ignited by lantern while filling car or truck	5
Gasoline ignited by match or smoking	5
Gasoline ignited when motor car tank overflowed on to exhaust pipe	4
Tank overflowed and gasoline ignited by open flame	3
Vapor ignited by spark from starter of electric pump	2
Vapor from pump disconnected for repairs ignited by open flame	1
Vapor from pipes under repair ignited by spark from tool	1
Gasoline discharged by mistake into fuel oil tank ignited at burner	1
Fire occurred in pump room—cause not known	1
Tank ignited by spark from wires caused by workman	1

Little need be said of oily material as a fire hazard. Ordinarily classified as a common hazard, its particular presence in garages justifies its inclusion as a special hazard under garage fire causes. All fires from this cause were preventable.

Spontaneous Ignition.

	No. Fires
Spontaneous ignition of oily clothing or waste	12
Spontaneous ignition of oily stock under bench	5
Spontaneous ignition of oily stock, parts, etc., in wooden barrels	3
Spontaneous ignition of waste in boiler room	2
Spontaneous ignition of waste on steam pipes	2
Spontaneous ignition of oily stock which was greased to prevent rust	1
Waste left in overalls in wooden locker	2

The hazards incidental to vulcanizing seem to be less a factor in garage occupancies. This is probably due to the fact that tire service is being handled by tire service stations rather than as a function of regular garages. Improvements in equipment and operation have also undoubtedly been factors in the reduction of the number of fires from this cause.



International.

Seattle, Washington. Skeletons of automobiles which were stored on the second floor of one of the buildings. When the flooring gave way the cars, which were standing directly over a girder, were suspended by their front axles from the girder.

Vulcanizing.

	No. Fires
Defective vulcanizing machine	2
Explosion of vulcanizing machine	2
Plug in pressure gauge of vulcanizer blew out and gas ignited from hot stove	1
Open vulcanizer set fire to tire	1
Carelessness in vulcanizing	1

The remainder of the garage fire causes were as follows. The causes are self-explanatory for the most part, and would appear to be of a largely preventable nature.

	No. Fires
Battery charging	4
Sparks from emery wheel set fire to auto top	2
Explosion—acetylene (automobile) tank	2
Explosion—cause unknown	2
Drying auto seat cushions on top of boiler	1
Fire started around electric motor at air compressor	1
Pitch being heated for battery repairs boiled over and caught fire from gas flame	1
Overalls cleaned in gasoline ignited by open flame of gas hot-water heater	1

Common Causes.

To the hazards which garage heating systems share with those in every other occupancy must be added the danger of the ignition of fumes of volatile liquids. For this reason, furnaces should be housed either in a building wholly independent, or located in a room cut off from the main structure by fire walls or in the basement, with stairway entrance from the outside only. As a cause of garage fires, heating, including defective chimneys and flues, led the list of common causes. These fires were classified as follows:

	No. Fires
Sparks or flareback from boiler	12
Back-fire from oil burner	11
Defective oil burner	8
Overheated boiler, furnace or stove	8
Hot ashes	7
Overheated chimney or flue	7
Miscellaneous—Started around heater	6
Spontaneous ignition in coal	4
Small or portable oil heater	3
Hot bar used in furnace in contact with combustible material	3
Pipe too near partition	2
Explosion of heater	1

As might be expected, the cause of "Matches—Smoking" held its own for the period under review. There are not many occupancies where indulgence in smoking and the thoughtless use of matches are more certain in time to invite fire. Patrons are inclined to be careless and so, too, are employees. Constant handling of gasoline leads employees into that form of disregard which prompts them "to take a chance."

	No. Fires
Cigarette or match thrown in rubbish or waste material	21
Gasoline vapor ignited by smoking—specific data lacking	13
Smoking while filling tank	5
Cigarette tossed into auto	5
Pipe left in clothing	2
Cigarette thrown into alcohol tank	1
Miscellaneous—no specific data	7

Electrical causes claim their usual share of fires, with defective wiring and short circuits as the major factors. Fires classified under this cause include only those in which electrical causes are the contributory factor. When electrical causes are the primary factor in the ignition of flammable liquids or vapor they have been included under special hazard causes.

	No. Fires
Defective wiring	23
Short circuit—wiring	11
Overloading motor	9
Short circuit—motor	2
Fuse gap bridged with pennies	1
Short circuit—light outlet	1

Fire Engineering.

Garage fire in Chicago, 1927. One man, a cleaner, was trapped in a car while asleep, and fifty automobiles were destroyed. The loss was estimated at $150,000.

Rubbish and sweepings, exposure and incendiarism are common causes which need no explanation here. The ten fires classified as miscellaneous were fires from various causes common to any occupancy and have not been detailed.

Complete data as to the place of origin of the fires tabulated in the above record were not available. However, it has been possible to make a general summary as follows:

	Boiler Room	Garage	Repair Shop	Misc. Known Sections	Total
Automobile Causes	0	105	31	3	140
Garage Causes	8	85	94	23	210
Common Causes	69	51	27	50	197
Incendiary	0	11	0	2	13
Exposure	0	1	0	5	6
Unknown	2	79	14	12	107
Total	79	332	166	95	673

Sprinkler Fire Record.

In spite of the fact that claims have sometimes been made that the garage hazard is too severe for ordinary automatic sprinkler protection, and that application of a large volume of water is likely to spread the fire by floating burning gasoline, the records of the N.F.P.A. indicate no basis for such an opinion. In the N.F.P.A. files there are reports of 466 fires occurring in sprinklered garages covering a period from May, 1905, to December, 1928. Of these fires there were only seven in which there were failures of the sprinkler

In this fire in a Pittsfield, Mass., garage, a fire originating in a closed car was confined to its point of origin by the operation of three sprinklers. The complete burning of the interior of this car affords evidence of what might have happened to the other cars in the garage but for sprinkler protection.

system reported, making a total of 459 fires, or 98.5%, where the operation of sprinklers was satisfactory. This compares most favorably with a general average of 96.0% for all classes of occupancy.

Of the seven failures, four were due to water shut off sprinklers, two were due to obstructions to distribution, and one due to miscellaneous causes.

Included in the tabulation of fires occurring from January, 1921, to December, 1928, inclusive, were 376 fires occurring in sprinklered garages. Of these fires there were 83 where sprinklers were not a factor, leaving 293 for analysis. Of these 286, or 97.6%, the sprinkler operation was satisfactory.

Comparison of Wet and Dry Systems.

	Wet	Per Cent	Dry	Per Cent	Total	Per Cent
Extinguished Fire..	168	67.2	28	65.1	196	66.8
Held Fire in Check.	80	32.0	11	25.6	91	30.8
Unsatisfactory	2	.8	4	9.3	6	2.4
Total.....	250	100.0	43	100.0	293	100.0

The four unsatisfactory fires involving dry systems were occasioned by water being shut off sprinklers, and the two involving wet systems were due to obstructions to effective distribution.

Analysis of Sprinkler Operation.

No. of Heads Opening	No. of Fires Wet Systems	Dry Systems	Total	Per Cent
1	111	8	119	40.6
2	74	8	82	27.9
3	22	1	23	7.8
4	5	2	7	2.4
5	4	0	4	1.5
6-9	18	5	23	7.8
10-25	7	9	16	5.5
26-50	2	4	6	2.0
No Data	7	6	13	4.5
Total	250	43	293	100.0

Analysis of Loss.

	Wet	Per Cent	Dry	Per Cent	Total	Per Cent
Small Loss	240	96.0	37	86.1	277	94.5
Large Loss (Over $5000)	5	2.0	5	11.6	10	3.4
No Data	5	2.0	1	2.3	6	2.1
Total	250	100.0	43	100.0	293	100.0

Loss of Life in Garage Fires.

In compiling the fire record for garages for the period 1921 to 1928 there were found to be thirteen fires in which loss of life occurred. For the greater part these were occupants or employees of garages, and the table below clearly indicates the cause of such fires.

Loss of Life in Garage Fires.

Number of fires in which lives were lost 13

	Number	Per Cent
Men killed	27	84.4
Women killed	2	6.2
Children killed	3	9.4
Total number of lives lost	32	100.0
Loss of life per fire included in this table	..	2.5

Causes of Loss of Life in Garages.

Fatalities classified according to the immediate cause of the loss of life rather than according to the cause of the fire.

	No. Fires
Gasoline vapor in contact with open flame	13
Explosion—exact cause unknown	4
Trapped while sleeping in garage	3
Gasoline ignited by carelessly thrown match	3
Explosion caused by welding unvented tank	2
Gasoline spilled on clothing ignited by cigarette	1
Nozzle of sprayer struck ignition wire, causing spark which ignited gasoline vapor	1
Gasoline tank overflowed and gasoline ignited from ash pit, flashing back and cutting off escape	1
Explosion of acetylene torch	1
Trying to remove car from burning garage	1
Falling bricks strike fire fighters	1
Burned trying to extinguish fire	1
Total	32

Paramount Studio Fire.

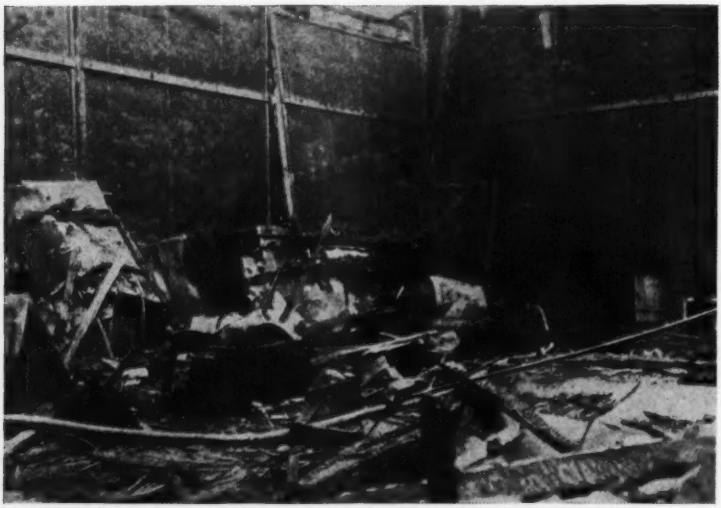
By Henry Anderson,

Paramount-Famous-Lasky Corporation.

At about six o'clock P.M. on January 16, 1929, a fire was discovered in the new sound studio then in course of construction for Paramount-Famous-Lasky Corporation in its Hollywood studio. When discovered, the fire had apparently been burning for some time and had gained substantial headway. By the time the fire department arrived the fire was out of control, and as a result the building was damaged to such an extent that it will have to be practically rebuilt.

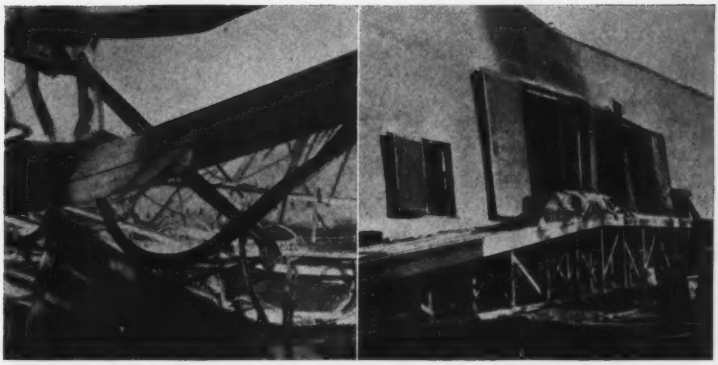
The cause of this fire will probably never be known and it is purely a matter of conjecture. Inasmuch as the building was in course of construction, and mechanics were employed, it is fair to assume that the fire was started by some cause incidental to construction.

The building was necessarily of large size, about 220 ft. by 200 ft. The walls of the outside structure were of tile, and the roof was of wood on unprotected steel roof trusses. The outer structure or shell housed four separate sound proof stages, together with certain electrical equipment used in connec-



Fireman's Fund Record.

A sound studio of the Paramount-Famous-Lasky Corporation in course of construction at Hollywood, Cal., was destroyed by fire on January 16, 1929, with a loss estimated at half a million dollars. This picture shows the complete destruction of the interior walls.



Fireman's Fund Record.

The steel roof trusses were a total loss, as shown by the photograph at the left. The picture at the right shows the buckling and total loss of the exterior walls.

tion with sound recording. The principal sound recording apparatus, however, was located outside the studio and in a separate fire-resistive building, which was undamaged.

This was one of the first sound stages ever constructed. There were no precedents to follow, and the design and materials of construction were based on recommendations of scientists who had specialized on sound. Sound requirements had to be given first consideration. Studies were made of various building materials, and while, for example, concrete would have been ideal from a fire standpoint, concrete would not have the necessary sound insulating properties; its sound conducting qualities prohibiting its use.

The design was based on obtaining the greatest amount of sound insulation possible for each of the four separate stages. This was accomplished by breaking up the walls of these boxes or stages into layers with dead air space between. The insulating materials, forming the dead air space, were part noncombustible and part combustible, although none of the materials used for insulation would have been regarded as highly flammable.

Probably the great weakness of the building was its large area. Second to that were the concealed wall spaces, which gave the fire an opportunity to gain considerable headway before it was detected. Another factor contributing to the loss was the difficulty in getting water at the seat of the fire; this again brought about by the concealed wall spaces and aggravated by the large area. An automatic sprinkler system was to have been installed.

We were confronted with the problem of rebuilding as quickly as possible. Immediately following the fire we had our engineers restudy the entire question, and further investigations were made as to the sound-proofing qualities of materials which have not heretofore been used. It was found possible as a result of the lesson learned by this fire to improve greatly the

Paramount-Famous-Lasky Corporation.

The new sound studio is of superior construction, designed to prevent any repetition of the previous fire.

design from the fire protection standpoint and to use certain non-combustible materials in place of the vegetable fibers formerly employed.

We incorporated the following improvements in our redesign:

1. What was a single area has been subdivided into ten separate areas by means of 21 in. terra cotta tile walls, extending from the ground through the roof. This will overcome one of the major weaknesses which existed in the old building.

2. Entire building is to be equipped with a system of automatic sprinklers.

3. Non-combustible sound insulating materials composed of gypsum, asbestos and mineral wool were substituted entirely for soundproofing materials manufactured from vegetable fiber.

4. Former concealed spaces in walls have been left open and the automatic sprinklers have been arranged so that they may discharge into the spaces without obstruction.

5. The sides of the walls forming the concealed spaces consist entirely of asbestos or similar board, so that there is no exposed combustible surface.

6. It was found necessary to use wood studding to some extent, but the studding supports non-combustible material only, and fire stops have been installed in all of the spaces where the wood studding exists, dividing it up into practically a honeycomb and thus substantially retarding spread of fire.

7. The original studio was equipped with inside standpipe and hose, and this feature will be incorporated in the new design.

8. Removable hatches are being provided in the roof, giving access to the roof space.

9. Permanent iron ladders are being provided outside the building, leading from the ground to the roof.

10. All ventilating ducts, where they pass through the walls, are being equipped with standard automatic fire dampers.

11. A standard system of fire fighting equipment consisting of extinguishers, axes, ladders, etc., will be provided.

12. Central station watchman service and fire alarm system will be provided such as was being installed in the previous building.

13. Adequate outside hydrant protection will be provided as in the old building.

14. Roof monitors are to be provided for protection against exposing buildings.

15. Hand hose is to be provided on roof for protection of roof against embers from exposure fire.

Continued experiments and study will be given by our engineering and technical staffs to the development of improved materials, design and devices for the purpose of improving any sound stages which may subsequently be erected.

This solution of our problem goes far toward meeting fire protection requirements as far as is considered possible in view of the limitations dictated by the necessity for sound picture production of the highest quality.

Fires in Which There Was Loss of Life.

These notes are intended to point out typical conditions under which loss of life has occurred that they may be known and guarded against.

Apartment House Fire.

H-27103. WASHINGTON, D. C., JANUARY 21, 1929. A young woman was burned to death when she discovered a serious fire in the apartment house in which she lived. After shouting "fire" over the telephone, she opened a door to the dumb waiter shaft, up which the flames were shooting, and was enveloped in flames. Her mother and sister tried to etxinguish her burning night clothing with blankets, but she was fatally burned and died in a hospital. Due to the promptness with which she gave the alarm, other occupants of the building escaped.

Ashes from Stove Ignited Clothing.

L-364. STOUGHTON, MASS., JANUARY 13, 1929. An eighty-one-year-old woman was burned to death when hot ashes which she was carrying from her home set fire to some curtains, the flames from which communicated to her clothing.

Automobile Accident.

H-27106. EASTCHESTER, N. Y., FEBRUARY 6, 1929. An insurance man was killed, his partner was seriously injured, and two other men escaped with slight burns when the car in which they were riding crashed into a telegraph pole and burst into flames. The two in the rear seat were unable to escape before the fire department arrived, because the rear doors were jammed against their frames. The driver was driving while under the influence of liquor.

Bedclothing Ignited.

L-374. DENVER, COLO., FEBRUARY 7, 1929. An eighty-one-year-old woman was burned to death when the covers of her bed caught fire from a nearby grate. She had been ill for several months, but managed to run into another room, where she was found dead by persons who came in answer to her screams for help.

L-359. WINSLOW, ME., JANUARY 23, 1929. Confined to his bed by his illness, a boy was burned to death when his younger brother accidentally set the bed clothing afire. The younger brother was rescued.

Camp Fire Ignited Clothing.

L-358. SPARTANBURG, S. C., FEBRUARY 3, 1929. A ninety-year-old Confederate veteran died in a hospital from burns received when his clothing caught fire as he dozed off beside his camp fire. He had pitched camp beside his mule-drawn wagon in which he was traveling to a Confederate reunion when the accident occurred.

Explosion of Ethylene Gas.

H-27101. EVANSVILLE, IND., JANUARY 3, 1929. A surgeon at a hospital laboratory was instantly killed and his body was blown to bits when a drum of ethylene gas, which he was trying to repair, exploded. A spark caused by friction against metal on the drum is believed to have ignited the gas. The body was blown through a six-inch wall. Two receiving rooms were almost wholly destroyed. An assistant was seriously injured.

Fireworks.

L-370. HAZARD, KY., DECEMBER 24, 1928. The custom prevalent in the South of celebrating Christmas with fireworks cost the lives of four children when a firecracker, tossed in fun, landed in a can of blasting powder.

H-27100. CARTERSVILLE, GA., DECEMBER 24, 1928. Four children who were earning Christmas money as temporary clerks in a fireworks store were claimed by death when a roman candle, lighted by a customer, caused an explosion which enveloped the building in flames. The proprietor told the police that an unknown man entered the store while several persons were shopping and snatched a large roman candle from a counter. Before he could be stopped, the man lighted the fuse and began firing the hot balls of flame out of the store. Other fireworks were ignited and the store was immediately enveloped in flames, only a few of those in the building escaping without burns.

Furnace Ignited Night Clothes.

L-371. BROOKLYN, N. Y., DECEMBER 30, 1928. A five-year-old child was fatally burned when she went into the cellar of her home alone to look for her pet kitten. Her nightdress ignited from the furnace and the flames prevented anyone entering the cellar until it was too late to save her.

Insane Woman Started Fire.

L-378. ST. PAUL, MINN., DECEMBER 5, 1928. A woman, who was slightly insane, built a fire in a wash tub in the middle of her kitchen floor instead of using the stove. The floor under the tub became ignited and the woman was suffocated before she could get out of the house. She was found near the rear door after the fire was out.

Kerosene Used for Stove Fire.

L-369. YOUNGSTOWN, OHIO, JANUARY 1, 1929. A two-year-old boy was burned to death in a fire which followed an explosion which occurred when the father poured kerosene on the coals in a stove to stimulate the fire.

Fires Caused by Matches.

L-366. MARSEILLES, FRANCE, JANUARY 5, 1929. Two divers were burned to death while working under water. The men were sent down in a diving bell to stuff tow in a crack of a caisson. They had been down for some time and as no signals were heard from them, fellow workmen on the wharf pulled up the bell. The men were found in it asphyxiated and with their bodies badly burned. It is supposed that one of them lighted a match and that it accidentally set fire to the tow.

L-377. St. Paul, Minn., February 27, 1929. A woman was burned to death when she dropped a match, with which she had lighted a gas jet, into a pile of bedding. When she attempted to extinguish the fire herself her clothing caught fire and she burned to death before the fire was discovered by outsiders.

Fire Caused by a Kerosene Lamp.

L-343. Cambridge, Mass., December 25, 1928. In the house where four years before on Christmas eve her husband dropped dead, a seventy-five-year-old woman was burned to death. The remains of a kerosene lamp near her body indicated that it had fallen from her hands and started the flames which swept a four-family dwelling. The woman burned was an invalid and was unable to get out of the house unaided. She died from burns before firemen from a station just across the street reached her.

Oil Stoves.

L-348. Oceanville, N. J., December 14, 1928. A sixty-year-old cripple, who as a professional caddy had carried the clubs of several famous personages, was found burned to death near the front door of his home by firemen who came to fight a blaze there which is believed to have started from an oil stove.

L-346. Framingham, Mass., December 22, 1928. A young woman, employed as a domestic, died in a hospital from burns she received as she was lighting an oil stove at her place of employment.

L-353. Upton Station, Va., December 12, 1928. An oil stove exploding in the kitchen of her home while she was preparing breakfast caused fatal burns for a forty-three-year-old woman. The fire that resulted destroyed the house, and a son was injured when he leaped from a second story window. A neighbor was forced to swathe the woman in blankets before he could remove her from the building because she was so seriously burned.

Burns from a Peanut Roaster.

H-26983. Lowell, Mass., December 20, 1928. A woman lost her life as a result of severe burns she received when her clothing caught fire as she backed into a peanut roaster in her husband's fruit and confectionery store. He was burned in trying to extinguish her flaming clothing.

Smoking in Bed.

L-354. Pemberton, N. J., December 2, 1928. A farmer was burned to death when he apparently fell asleep while smoking a pipe in his bedroom on the second floor of his home. A farmhand was attracted by smoke pouring from the upper windows and almost at the same time saw the farmer trying to open one of them. He was overcome before he could be reached, and efforts to revive him failed.

L-351. Boston, Mass., December 10, 1928. First aid methods were of no avail when firemen tried to save the life of a man they pulled unconscious from the midst of his burning bed clothes. The man, who had been smoking in bed, was pronounced dead of smoke at the hospital.

Annual Sprinkler Tables.

Statistics of Fires in Properties Having Automatic Sprinkler Protection.

NOTE.—These tabulations are made at the close of each year with the object of furnishing a basis upon which the virtues of the automatic sprinkler as an extinguishing agent can be estimated.

Section I is devoted to fires in which the behavior of sprinklers was, for the reasons given, unsatisfactory.

Section II is a statistical record of all reports of sprinkler fires in the files of the Association upon which the information obtained is sufficiently complete for statistical purposes.

In each table the results of the current year ending February 1, 1929, are given, and these are compared with the results of the total thirty-three year record ending at that time.

The annual sprinkler tabulation is published this year for the thirty-third consecutive year. The tables show the actual fire experience with automatic sprinkler equipments in forty thousand fires. This is not intended as a complete statistical record of fires occurring in sprinklered properties; it includes only those fires reported to the Department of Fire Record in sufficient detail to give the data necessary for the tables. This is probably only a fraction of the total number of fires occurring in buildings under sprinkler potection, but with a total of 40,000 fires in the record and current reports being received at the rate of approximately two thousand a year, there can be no doubt but that this summary as a whole is typical and completely representative. An exception to this statement may be made in the case of the detailed records of experience in some occupancies where only a comparatively small number of fires are reported. In order to maintain the continuity of the tables from year to year it is necessary to have every occupancy classification appear, even though there be but one sprinklered fire reported. It is obvious, however, that conclusions should not be drawn as to the effectiveness of sprinklers in an occupancy where the number of fires reported is so small that the efficiency percentage may be distorted by the results of some one unusual fire.

The several tables showing sprinkler performance are divided into columns of cases where sprinklers "extinguished fire" and cases where sprinklers "held fire in check," both of these being classed as satisfactory performance. The distinction between these two classifications is necessarily more or less arbitrary, depending upon the judgment of the original inspector. The great majority of the fires in the "held in check" columns are cases where hose streams or chemicals were used to extinguish fire in spaces which water from the sprinkler did not reach because of obstructions to distribution, concealed spaces or unsprinklered portions, but where sprinklers functioned satisfactorily in preventing the spread of fire.

In preparing these tables it is the fixed policy of the Department of Fire Record never to give the sprinklers the benefit of the doubt. In cases where there is question as to whether a given fire should be classified as "Held in Check" or "Unsatisfactory," it is always placed in the "Unsatisfactory" column. The tables thus give a very conservative picture of the efficiency of sprinklers. Likewise it should be noted that there are doubtless a large number of fires annually which are extinguished by one or two sprinkler heads where no claim for loss is made and where no report reaches the Department of Fire Record. If it were possible to include the reports of all such fires in the tables the total percentage of sprinkler efficiency would approach much nearer to one hundred per cent.

The tables presented this year follow the same general plan and arrangement as in previous years. A few changes in occupancy classification have been made in order to keep the list of occupancies in as representative a form as possible. The classification originally designated as "Boots and shoes" has been changed to "Shoe factories." The classification designated as "Celluloid" has been changed to "Pyroxylin plastic manufacturing and fabrication." The "Creamery" classification has been changed to "Dairies and creameries."

In the 1928 tables there were 795 fires recorded in the miscellaneous occupancy classification, including a large number of occupancies in which there was not a sufficiently extensive record to justify a separate occupancy classification. As the total volume of fires in the records has increased it is possible to segregate from this miscellaneous classification a number of individual occupancies where there is a sufficient number of fires to make a separate classification worth while. The total fires classified as miscellaneous occupancy have now been reduced to 593 by the separate classification of the following occupancies:

Automobile Paint Shops	Mining Property
Buildings Under Construction	Mirror Manufacturing
Clock and Watch Factories	Optical Works
Coal and Wood Storage	Paper Coating Mills
Fruit Plants, Dried	Peanut Roasting Plants
Hair Works	Salt Works
Gum Manufacturing	Smelting and Refining
Ice Cream Factories	Umbrella Factories
Lamp Shade Factories	Vacant Buildings
Macaroni Factories	Wool Scouring Plants

The total number of sprinklered fire reports received during the past year was 1978. The number of fires in which the sprinklers were not a factor* or which were discovered and extinguished before there was sufficient heat to open the sprinklers was 576.

*By "not a factor" is meant fires that occur in unsprinklered portions of a building.

SECTION I.

Summary of Unsatisfactory Sprinkler Fires.

	1928-1929 No. of Fires	1928-1929 Per Cent	1897-1929 incl. No. of Fires	1897-1929 incl. Per Cent
Water shut off sprinklers	27	39.0	538	31.4
Generally defective equipment	5	7.3		
Unsprinklered portions	10	14.5	332	19.4
Defective water supply or supplies	6	8.7	153	8.9
Sprinkler system crippled due to freezing	1	1.4	44	2.5
Slow operation of dry system or defective valve	5	7.3	47	2.7
Slow or defective operation of high test heads	..	..	25	1.5
Faulty building construction, concealed spaces, vertical openings, etc.	2	2.9	86	5.0
Obstruction to distribution	1	1.4	93	5.4
Hazard of occupancy too severe for average sprinkler equipment	3	4.4	101	5.9
Explosion crippled sprinkler system	3	4.4	81	4.7
Exposure or conflagration	1	1.4	74	4.3
Plugged heads (included with Miscellaneous prior to 1921)	..	..	15	.9
Miscellaneous	5	7.3	128	7.4
Total	69		1717	

Fires in Which Failure Was Due to Water Shut Off Sprinklers.

	1928-1929 No. of Fires	1897-1929 No. of Fires
Water shut off for unknown reason, neglect or carelessness	3	175
Water shut off before fire was out or fire rekindled	3	85
Water shut off due to accidents or repairs	3	89
Water shut off to prevent freezing	12	127
Water shut off, probably incendiary	..	8
Water shut off, leaky dry system	..	11
Water shut off, defective gate valve	1	9
Water shut off, miscellaneous	5	34
Total	27	538

SECTION II.

Annual Revision of Sprinkler Fire Tables

In the following tables is given a summary of fires occurring in properties equipped with automatic sprinklers. The total number of such fires reported during the past year is 1978, which includes 576 fires where no sprinklers were opened. Several reports were also received in which the data were incomplete, and these were not used in the summary. It may be noted that the total number of fires does not agree throughout all the tables. This is because some of the reports of fires prior to 1909 were not considered sufficiently complete to include in all the tables, and hence appear in some tables, but not in others.

Table No 1—Number of Sprinklers Operating

No. of Fires, 1928-1929

No. of Sprinklers Operating	Wet	%	Dry	%	No Data	Total	%
1	446	41.6	65	24.5	13	524	37.4
2	202	18.9	29	10.9	10	241	17.4
3	86	8.0	29	10.9	2	117	8.4
4	65	6.1	15	5.7	1	81	5.8
5	52	4.9	10	3.7	7	69	4.9
6	31	2.9	11	4.1	2	44	3.1
7	27	2.5	8	3.0	0	35	2.5
8	21	2.1	12	4.5	1	34	2.4
9	16	1.5	8	3.0	1	25	1.8
10	19	1.8	9	3.4	0	28	2.0
11	11	1.0	2	.8	0	13	.9
12	12	1.1	8	3.0	1	21	1.5
13	6	.5	5	1.9	1	12	.8
14	3	.3	4	1.5	0	7	.5
15	10	.9	4	1.5	0	14	1.0
16-20	13	1.2	12	4.5	0	25	1.8
21-25	8	.7	4	1.5	1	13	.8
26-30	9	.8	7	2.6	1	17	1.2
31-35	8	.7	2	.8	0	10	.7
36-40	1	.1	5	1.9	0	6	.4
41-50	4	.4	4	1.5	0	8	.6
51-75	4	.4	3	1.1	0	7	.5
76-100	1	.1	3	1.1	0	4	.3
Over 100	7	.7	3	1.1	1	11	.7
No Data	9	.8	4	1.5	23	36	2.6
Total	1071	100.0	266	100.0	65	1402	100.0

No. of Fires, 1897-1929, inclusive

No. of Sprinklers Operating	Wet	%	Dry	%	No Data	Total	%
1	11944	36.9	1341	19.8	86	13371	33.5
2	5911	18.3	899	13.2	42	6852	17.3
3	3200	10.0	566	8.4	28	3794	9.5
4	2249	7.0	482	7.1	21	2752	6.9
5	1377	4.3	314	4.6	15	1706	4.3
6	1118	3.5	304	4.5	13	1435	3.6
7	770	2.4	226	3.4	7	1003	2.5
8	734	2.3	199	2.9	9	942	2.4
9	473	1.4	159	2.3	7	639	1.6
10	434	1.3	136	2.0	12	582	1.4
11	314	.9	117	1.7	4	435	1.1
12	356	1.1	141	2.1	7	504	1.3
13	208	.6	101	1.5	8	317	.8
14	241	.8	106	1.6	4	351	.9
15	202	.6	99	1.5	2	303	.7
16-20	680	2.1	293	4.3	13	986	2.5
21-25	400	1.3	221	3.4	6	627	1.5
26-30	284	.9	150	2.2	9	443	1.1
31-35	176	.5	99	1.5	3	278	.7
36-40	158	.5	91	1.3	4	253	.6
41-50	192	.7	118	1.7	3	313	.8
51-75	274	.8	169	2.5	2	445	1.1
75-100	121	.4	87	1.3	5	213	.6
Over 100	395	1.2	293	4.3	12	700	1.8
No Data	76	.2	63	.9	470	609	1.5
Total	32287	100.0	6774	100.0	792	39853	100.0
Water shut off sprinklers						297	
Total						40150	

Table No. 2—Number of Sprinklers Operating.

No. of Fires, 1897-1929, inclusive.

No. of Sprinklers Operating	Wet	%	Dry	%	No Data	Total	%
1	11944	36.8	1341	19.8	86	13371	33.5
2 or less	17855	55.5	2240	32.6	128	20223	50.6
3 or less	21055	67.0	2806	41.4	156	24017	60.2
4 or less	23304	72.3	3288	48.4	177	26769	67.5
5 or less	24681	76.5	3602	53.2	192	28475	71.2
6 or less	25799	79.3	3906	57.5	205	29910	76.6
7 or less	26569	82.5	4132	61.0	212	30913	77.4
8 or less	27303	84.5	4331	64.0	221	31855	79.6
9 or less	27776	85.7	4490	66.2	228	32494	81.5
10 or less	28210	87.0	4626	68.2	240	33076	82.8
11 or less	28524	88.2	4743	69.9	244	33511	89.0
12 or less	28880	89.5	4884	72.0	251	34015	85.4
13 or less	29088	89.8	4985	73.5	259	34332	86.0
14 or less	29329	90.7	5091	75.0	263	34683	86.8
15 or less	29531	91.2	5190	76.5	265	34986	87.7
20 or less	30211	93.5	5483	82.0	278	35972	90.2
25 or less	30611	94.8	5704	84.2	284	36599	91.5
30 or less	30895	95.5	5854	86.2	293	37142	92.8
35 or less	31071	96.0	5953	87.9	296	37320	93.5
40 or less	31229	96.8	6044	89.1	300	37573	94.0
50 or less	31421	97.3	6162	91.0	303	37886	95.0
75 or less	31695	98.1	6331	93.5	305	38331	96.0
100 or less	31816	98.5	6418	94.8	310	38544	96.5
Over 100	395		293		12	700	
No Data	76		63		470	609	
Total	32287		6774		792	39853	
Water shut off sprinklers						297	
Total						40150	

Table No. 3—Effect of Sprinklers.

	1928-1929 No. of Fires	%	1897-1929, incl. No. of Fires	%
Practically or entirely extinguished	975	69.7	26955	67.4
Held fire in check	358	25.6	11437	28.5
Total Satisfactory	1333	95.3	38392	95.9
Unsatisfactory	69	4.7	1717	4.1
Total	1402		40109	

Table No. 4—Effect of Sprinklers by Class of Occupancy.

	Extinguished Fire		Held Fire in Check		Total Satisfactory		Unsatisfactory		Total No. of Fires
	No.	%	No.	%	No.	%	No.	%	
Abrasive Works	11	64.8	4	23.5	15	88.3	2	11.7	17
Aeroplane Factories	3	50.0	3	50.0	6	100.0	..	..	6
Agricultural Implement Mfg.	62	57.4	41	37.9	103	95.3	5	4.7	108
Alcohol Distilleries	..	..	1	100.0	1	100.0	..	..	1
Aluminum Works	3	60.0	2	40.0	5	100.0	..	..	5
Amusement Resorts	2	66.7	1	33.3	3	100.0	..	..	3
Apartment Houses	76	88.0	9	12.0	85	100.0	..	..	85
Artificial Flower Mfg.	15	100.0	..	..	15	100.0	..	..	15
Artificial Leather Mfg.	19	42.2	23	51.1	42	93.3	3	..	45
Asbestos Works	12	54.6	8	36.4	20	91.0	2	..	22
Automobile and Bicycle Factories.	201	58.6	125	36.5	326	95.1	17	..	343
Automobile Paint Shops	8	89.0	1	11.0	9	100.0	..	..	9
Awning Factories	6	66.7	3	33.3	9	100.0	..	..	9
Bag Factories	40	63.5	20	31.8	60	95.3	3	4.7	63
Bakeries	124	73.4	38	22.5	162	95.9	7	4.1	169
Basket Factories	9	90.0	1	10.0	10	100.0	..	..	10
Battery Mfg. Plants	21	65.5	10	31.3	31	96.8	1	3.2	32
Bolt, Nut and Screw Works	22	59.5	13	35.1	35	94.6	2	5.4	37
Bottle Caps and Seals Mfg.	26	51.0	24	47.0	50	98.0	1	2.0	51
Bottling Works	5	62.5	2	25.0	7	87.5	1	12.5	8
Bowling Alleys, Pool Rooms, etc.	11	100.0	..	..	11	100.0	..	..	11
Braid Mills	40	80.0	8	16.0	48	96.0	2	4.0	50
Brass Works	67	70.5	25	26.5	92	97.0	3	3.0	95
Breweries	5	83.4	1	16.6	6	100.0	..	..	6
Broom Factories	13	56.5	8	34.8	21	91.3	2	8.7	23
Brush Factories	27	69.2	12	30.8	39	100.0	..	..	39
Buildings Under Construction	..	..	1	100.0	1	100.0	..	..	1
Button Factories	63	83.0	11	14.5	74	97.5	2	2.5	76
Candle Factories	6	46.1	7	53.9	13	100.0	..	..	13
Candy Factories	171	72.2	57	24.0	228	96.2	9	3.8	237
Canning Factories	17	63.0	7	25.8	24	88.8	3	11.2	27
Car Houses	34	43.6	36	46.2	70	89.8	8	10.2	78
Car Works	86	61.4	49	35.0	135	96.4	5	3.6	140
Carpet and Rug Mills	177	62.4	97	34.2	274	96.6	10	3.4	284
Carriage & Auto Body Factories.	139	58.6	77	32.6	216	91.2	21	8.8	237
Cement and Plaster Works	11	73.4	2	13.3	13	86.7	2	13.3	15
Cereal Mills	37	62.7	14	23.8	51	86.5	8	13.5	59
Chemical and White Lead Works.	136	59.2	75	32.6	211	91.8	19	8.2	230
Clock and Watch Factories	9	75.0	3	25.0	12	100.0	..	..	12
Clothing Factories	1810	85.0	287	13.5	2097	98.5	16	1.5	2113
Clubs	19	70.5	6	22.2	25	92.7	2	7.3	27
Coal and Wood Storage	2	50.0	2	50.0	4	100.0	..	..	4
Coffee and Spice Mills	73	68.8	29	27.4	102	96.2	4	3.8	106
Coffin and Casket Factories	64	72.8	20	22.7	84	95.5	4	4.5	88
Cold Storage Plants	9	64.3	5	35.7	14	100.0	..	..	14
Cooperage Plants	53	58.2	27	29.7	80	87.9	11	12.1	91
Cordage Works	232	64.3	116	32.2	348	96.5	13	3.5	361
Cork Factories	29	47.6	27	44.3	56	91.9	5	8.1	61

	Extinguished Fire		Held Fire in Check		Total Satisfactory		Unsatisfactory		Total No. of Fires
	No.	%	No.	%	No.	%	No.	%	
Corset Factories	11	68.9	4	24.9	15	93.8	1	6.2	16
Cotton Gins	8	61.6	5	38.4	13	100.0	..	..	13
Cotton Mills	4670	62.4	2714	36.3	7384	98.7	99	1.3	7483
Cotton Seed Oil Mills	40	48.2	29	35.0	69	83.2	14	16.8	83
Cotton Warehouses	161	46.6	157	45.4	318	92.0	28	8.0	346
Cutlery and Tool Mfg.	30	62.5	16	33.3	46	95.8	2	4.2	48
Dairies and Creameries	4	100.0	..	..	4	100.0	..	..	4
Department Stores	545	78.6	128	18.5	673	97.1	21	2.9	694
Distilleries	10	62.5	5	31.3	15	93.8	1	6.2	16
Doll Factories	51	60.0	34	40.0	85	100.0	..	..	85
Drug Mfg. and Warehouses	209	81.1	45	17.4	254	98.5	4	..	258
Dry Cleansing Establishments	10	52.7	9	47.3	19	100.0	..	..	19
Dry Goods Stores	323	85.7	49	13.0	372	98.7	5	1.3	377
Dwelling	..	..	..	..	..	..	1	100.0	1
Dyeing, Bleaching and Finishing	187	53.9	146	42.1	333	96.0	14	4.0	347
Electrical Appliance Mfg.	331	69.0	140	29.2	471	98.2	9	1.8	480
Electric Light and Power Plants	6	37.6	7	43.7	13	81.3	3	18.7	16
Elevators, Grain	32	38.2	29	34.6	61	72.8	23	27.2	84
Excelsior Factories	28	66.7	10	23.8	38	90.5	4	9.5	42
Fertilizer Plants	29	64.5	12	26.6	41	91.4	4	8.9	45
Fireworks Plants	..	..	1	100.0	1	100.0	..	..	1
Flax and Linen Mills	39	52.6	35	47.4	74	100.0	..	..	74
Flour and Grist Mills	77	55.8	38	27.7	115	83.5	23	16.5	138
Forge and Smithy	19	70.4	7	25.9	26	96.3	1	3.7	27
Foundries	193	58.7	120	36.4	313	95.1	16	4.9	329
Fruits, Dried, Plants	1	100.0	..	..	1	100.0	..	..	1
Fur Mfg.	115	94.4	5	4.1	120	98.5	2	1.5	122
Furniture Factories	756	66.0	302	26.3	1058	92.3	91	7.7	1149
Furniture Stores	83	76.8	20	18.5	103	95.3	5	4.7	108
Garages	324	69.5	135	29.0	459	98.5	7	1.5	466
Garbage Reduction Plants	3	60.0	1	20.0	4	80.0	1	20.0	5
Gas Works	2	40.0	2	40.0	4	80.0	1	20.0	5
General Stores	27	78.0	8	22.0	35	100.0	..	..	35
Glass Factories	66	51.9	47	37.0	113	88.9	14	11.1	127
Glove Factories	15	75.0	4	20.0	19	95.0	1	5.0	20
Glue Factories	9	47.4	8	42.1	17	89.5	2	10.5	19
Groceries	146	77.6	33	17.5	179	95.1	9	4.9	188
Gum Mfg.	6	86.0	1	14.0	7	100.0	..	..	7
Hair Works	20	80.0	5	20.0	25	100.0	..	..	25
Hardware Stores	105	82.8	20	15.7	125	98.5	2	1.5	127
Harness and Fancy Leather Mfg.	157	82.6	31	16.3	188	98.9	2	1.1	190
Hat Factories	278	78.2	65	18.3	343	96.5	12	3.5	355
Hatters' Fur Works	17	51.5	10	30.3	27	81.8	6	18.2	33
Hotels	63	75.0	19	22.6	82	97.6	2	2.4	84
Ice Mfg. Plants	2	66.7	1	33.3	3	100.0	..	..	3
Ice Cream Factories	1	20.0	4	80.0	5	100.0	..	..	5
Idle Property	2	11.8	2	11.8	4	23.6	13	76.4	17
Incandescent Lamp Works	25	65.8	13	34.2	38	100.0	..	..	38
Institutions	17	65.4	8	30.8	25	96.2	1	3.8	26

	Extinguished Fire		Held Fire in Check		Total Satisfactory		Unsatisfactory		Total No. of Fires
	No.	%	No.	%	No.	%	No.	%	
Insulated Wire Works	43	63.2	24	35.3	67	98.5	1	1.5	68
Jewelry Factories	173	85.2	24	11.8	197	97.0	6	3.0	203
Junk Shops	24	73.6	8	24.2	32	97.8	1	2.2	33
Knitting Mills, Cop Yarn	67	68.5	25	25.5	92	94.0	7	6.0	98
Knitting Mills, Full Process	535	65.5	254	31.1	789	96.6	27	3.4	816
Lamp Shade Factories	21	95.5	1	4.5	22	100.0	..	..	22
Laundries	103	72.5	35	17.6	138	90.1	4	9.9	142
Lead Pencil Factories	18	69.2	7	26.9	25	96.1	1	3.9	26
Linseed Oil Works	20	51.3	12	30.8	32	82.1	7	17.9	39
Macaroni Factories	8	66.7	2	16.6	10	83.3	2	16.7	12
Machine Shops and Works	339	68.0	136	27.2	475	95.2	24	4.8	499
Mail Order Houses	41	91.0	4	9.0	45	100.0	..	..	45
Match Factories	60	75.2	15	18.8	75	94.0	4	6.0	79
Mattress Factories	481	68.9	206	29.4	687	98.3	13	1.7	700
Mercantile (Miscellaneous)	850	81.7	165	15.8	1015	97.5	29	2.5	1044
Metal Reduction Plants	11	68.9	5	31.1	16	100.0	..	..	16
Metal Workers†	1006	63.3	520	32.7	1526	96.0	65	4.0	1591
Mining Property	2	50.0	1	25.0	3	75.0	1	25.0	4
Mirror Mfg	14	87.5	2	12.5	16	100.0	..	..	16
Miscellaneous	439	74.0	128	21.5	567	95.5	26	4.5	593
Morocco Lea'r (see also Tanneries)	54	53.0	36	35.3	90	88.3	12	11.7	102
Motion Pictures (Theatres, Studios, Exchanges)	96	80.6	16	13.4	112	94.0	7	6.0	119
Multiple Occupancy	15	62.5	7	29.2	22	91.7	2	8.3	24
Munition Plants	25	44.7	22	39.3	47	84.0	9	16.0	56
Musical Instrument Factories	147	69.0	59	27.7	206	96.7	7	3.3	213
Office Buildings	59	86.8	9	13.2	68	100.0	..	..	68
Oil Cloth and Linoleum Works	48	31.6	82	53.9	130	85.5	22	14.5	152
Oil Clothing Factories	13	68.4	5	26.3	18	94.7	1	5.3	19
Oil Refineries—Animal	2	40.0	3	60.0	5	100.0	..	..	5
—Mineral	6	60.0	4	40.0	10	100.0	..	..	10
—Vegetable	7	41.1	8	47.0	15	88.1	2	11.9	17
Optical Works	13	52.0	12	48.0	25	100.0	..	..	25
Packing Houses	167	70.4	61	25.8	228	96.2	9	3.8	237
Paint and Varnish Works	244	65.1	116	31.0	360	96.1	14	3.9	374
Paper Box and Paper Products	267	77.3	72	20.8	339	98.1	7	1.9	346
Paper Coating Mills	17	70.6	5	20.8	22	91.4	2	8.6	24
Paper Mills	506	50.4	409	40.6	915	91.0	92	9.0	1007
Patent Leather (see also Tanneries)	12	35.3	17	50.0	29	85.3	5	14.7	34
Peanut Roasting Plants	1	50.0	1	50.0	2	100.0	..	..	2
Phonograph Works	29	72.5	10	25.0	39	97.5	1	2.5	40
Photograph Establishments	44	72.2	16	26.2	60	98.4	1	1.6	61
Picture Frame Mfg	49	66.2	19	25.7	68	91.9	6	8.1	74
Piers and Wharves	11	47.8	10	43.5	21	91.3	2	8.7	23
Plumbers' Supplies	33	73.4	12	26.6	45	100.0	..	..	45
Potteries	53	64.0	24	28.9	77	92.9	6	7.1	83
Printing and Lithographing	885	81.2	183	16.8	1068	98.0	20	2.0	1088
Public Buildings	1	50.0	1	50.0	2	100.0	..	..	2
Pulp Mills	36	33.6	46	42.5	82	76.1	25	23.9	107
Pyroxylin Plastic Mfg. & Fabricat'g	195	66.5	67	19.4	262	85.9	31	4.1	293

† See note on Metal Workers under Table No. 5.

	Extinguished Fire		Held Fire in Check		Total Satisfactory		Unsatisfactory		Total No. of Fires
	No.	%	No.	%	No.	%	No.	%	
Radios and Accessories	27	82.8	4	12.2	31	95.0	2	5.0	33
Railroad Property	2	22.2	6	75.0	8	97.2	1	2.8	9
Restaurants	89	71.6	31	26.2	120	97.8	3	2.2	123
Rice Mills	2	40.0	1	20.0	3	60.0	2	40.0	5
Rolling, Wire and Tube Mills	41	55.4	30	40.6	71	96.0	3	4.0	74
Roofing Works	36	39.2	47	51.2	83	90.4	9	9.6	92
Rubber Cloth Factories	35	56.5	24	36.7	59	93.2	3	6.8	62
Rubber Reclaiming Works	10	38.5	10	38.5	20	77.0	6	33.0	26
Rubber Mills	183	48.8	171	45.6	354	94.4	21	5.6	375
Salt Works	1	33.3	2	66.7	3	100.0	..	..	3
Saw and Planing Mills	97	41.3	82	34.9	179	76.2	56	23.8	235
Schools	18	82.0	4	18.0	22	100.0	..	..	22
Ships and Shipyards	9	53.0	7	41.1	16	94.1	1	5.9	17
Shoddy Mills	245	67.1	98	26.8	343	94.9	22	5.1	365
Shoe Factories	773	73.3	242	23.2	1015	96.5	37	3.5	1052
Shoe Mfg. Accessories	73	67.6	31	28.7	104	96.3	4	3.7	108
Shoe Stores	67	89.3	8	10.7	75	100.0	..	..	75
Silk Mills	135	78.5	32	18.6	167	97.1	5	2.9	172
Skin Mfg. (see also Tanneries)	12	66.7	5	27.8	17	94.5	1	5.5	18
Smelting and Refining	2	40.0	3	60.0	5	100.0	..	..	5
Soap Manufacturing	41	73.3	13	23.2	54	96.5	2	3.5	56
Stables	17	74.0	6	26.0	23	100.0	..	..	23
Stamping and Sheet Metal Works	112	57.2	69	35.2	181	92.4	15	7.6	196
Starch and Glucose Works	14	53.8	4	15.4	18	69.2	8	30.8	26
Sugar Refineries	33	55.0	25	41.7	58	96.7	2	3.3	60
Tanneries	54	52.5	41	39.8	95	92.3	8	7.7	103
Tenant Buildings	920	75.6	235	19.3	1155	94.9	63	5.1	1218
Theatres	64	71.9	19	21.4	83	93.3	6	6.7	89
Tobacco Factories	73	72.3	25	24.7	98	97.0	3	3.0	101
Trunk Factories	37	77.0	8	16.7	45	93.7	3	6.3	48
Umbrella Mfg.	13	76.5	3	17.6	16	94.1	1	5.9	17
Vacant Buildings	15	71.5	5	23.8	20	95.3	1	4.7	21
Wall Paper Factories	23	69.6	6	18.2	29	87.8	4	12.2	33
Warehouses	482	70.8	162	23.8	644	94.6	36	5.4	680
Waste and Batting Mills	326	61.3	186	35.0	512	96.3	20	3.7	532
Waste Paper and Rag Shops	116	64.2	59	32.6	175	96.8	6	3.2	181
Weaving Mills	153	66.8	69	30.2	222	97.0	7	3.0	229
Window Shade Factories	14	77.9	2	11.1	16	89.0	2	11.0	18
Woodworkers, Class A*	179	54.8	103	31.5	282	86.3	45	13.7	327
Woodworkers, Class B*	176	53.0	126	38.0	302	91.0	30	9.0	332
Woodworkers, Class C*	155	61.5	83	32.9	238	94.4	14	5.6	252
Woodworkers, Class D*	113	57.7	61	31.1	174	88.8	22	11.2	196
Woodworkers, Class E*	222	66.7	97	29.1	319	95.8	14	4.2	333
Woodworkers, Class F*	42	60.0	24	34.3	66	94.3	4	5.7	70
Woolen Mills	1033	69.8	376	25.4	1409	95.2	69	5.8	1478
Wool Scouring Plants	28	70.0	10	25.0	38	95.0	2	5.0	40
Wool Storehouses	28	68.4	11	26.7	39	95.1	2	4.9	41
Worsted Mills	78	57.3	44	32.3	122	89.6	14	10.4	136
Total Sprinkler Fires	26,955		11,437		38,392		1,717		40,109

* See detailed classification of Woodworkers as given under Table 5.

Table 5—Classification of Unsatisfactory Sprinkler Fires by Occupancy.

	Water shut off sprinklers.	Generally defective equipment and unsprinklered portions.	Defective water supply or supplies.	Sprinkler system crippled due to freezing.	Slow operation of dry system or defective dry valve.	Slow or defective operation of high test heads.	Faulty building construction, concealed spaces, vertical openings.	Obstruction to distribution.	Hazard of occupancy too severe for average sprinkler equipment.	Sprinkler system crippled by explosion.	Exposure or conflagration.	Plugged heads.	Miscellaneous.	Total.
Abrasive Works	..	1	..	..	..	..	..	..	..	..	..	..	1	2
Agricultural Implem'ts Mfg.	3	1	..	..	..	..	..	..	1	..	..	..	..	5
Artificial Leather	..	..	..	..	..	..	1	..	..	2	..	..	..	3
Asbestos Plants	..	..	1	..	..	..	..	..	..	1	..	..	..	2
Auto and Bicycle Factories.	7	2	1	..	..	..	..	4	..	2	1	..	..	17
Bag Factories	..	..	..	..	..	1	..	1	..	..	..	1	..	3
Bakeries	3	1	..	..	..	..	1	..	..	..	..	..	2	7
Battery Mfg. Plants	1	..	..	..	..	..	..	..	..	..	..	..	..	1
Bolt, Nut and Screw Works	1	1	..	..	..	..	..	..	..	..	..	..	..	2
Bottling Works	..	1	..	..	..	..	..	..	..	..	..	..	..	1
Braid Mills	..	1	..	..	..	..	..	1	..	..	..	..	..	2
Brass Works	1	1	..	..	..	..	..	..	..	..	..	..	1	3
Broom Factories	2	..	..	..	..	..	..	..	..	..	..	..	..	2
Button Factories	..	..	..	2	..	..	..	..	..	..	..	..	..	2
Candy Factories	3	..	..	1	1	..	2	..	1	..	..	..	1	9
Canning Factories	1	..	..	..	1	..	..	..	..	..	1	..	..	3
Car Houses	2	3	1	..	1	..	..	1	..	..	..	..	..	8
Car Works	2	1	..	..	..	..	1	1	..	..	..	..	..	5
Carpet and Rug Mills	4	2	3	..	..	..	..	1	..	..	..	..	..	10
Carriage and Automobile Body Factories	4	5	3	..	2	..	..	2	1	1	2	1	..	21
Cement and Plaster Works.	..	1	..	..	1	..	..	..	..	..	..	..	..	2
Cereal Mills	..	2	1	..	..	..	..	1	..	4	..	..	..	8
Chemical & White Lead Wks.	3	5	..	..	..	..	..	..	5	5	..	..	1	19
Clothing Factories	5	1	2	1	..	..	4	2	..	..	1	..	..	16
Clubs	1	..	..	..	..	..	1	..	..	..	..	..	..	2
Coffee and Spice Mills	2	..	..	..	..	..	..	1	..	1	..	..	..	4
Coffin and Casket Factories.	2	..	..	1	..	..	1	..	..	..	..	..	..	4
Cooperage Plants	1	4	..	..	..	1	..	4	..	..	1	..	..	11
Cordage Works	4	4	1	1	..	..	..	2	..	..	..	..	1	13
Cork Factories	1	..	1	..	..	..	..	..	1	1	..	..	1	5
Corset Factories	..	..	..	..	..	..	..	..	..	..	1	..	..	1
Cotton Mills	32	24	11	2	2	1	5	2	3	..	..	3	14	99
Cotton Seed Oil Mills	3	5	2	..	..	..	..	..	1	..	..	..	3	14
Cotton Warehouses	14	1	2	..	..	..	1	4	2	..	..	..	4	28
Cutlery and Tool Mfg.	1	1	..	..	..	..	..	..	..	..	..	..	..	2
Department Stores	9	6	..	..	1	..	1	1	..	..	2	..	1	21
Distilleries	..	..	..	..	..	..	..	..	..	..	1	..	..	1
Drug Mfg. and Warehouses	..	..	..	..	..	..	..	..	..	..	3	..	1	4
Drv Goods Stores	4	..	..	..	..	..	..	1	..	..	..	..	..	5
Dwellings	..	..	..	..	..	..	..	..	..	..	..	..	1	1
Dyeing, Bleach'g & Finish'g	5	3	1	..	1	1	..	1	..	..	1	..	1	14
Electrical Appliances	2	..	2	..	..	..	1	1	..	1	..	..	2	9
Elec. Light & Power Plants	1	1	..	..	..	..	..	1	..	..	..	..	..	3

	Water shut off sprinklers.	Generally defective equipment and unsprinklered portions.	Defective water supply or supplies.	Sprinkler system crippled due to freezing.	Slow operation of dry system or defective dry valve.	Slow or defective operation of high test heads.	Faulty building construction, concealed spaces, vertical openings.	Obstruction to distribution.	Hazard of occupancy too severe for average sprinkler equipment.	Sprinkler system crippled by explosion.	Exposure or conflagration.	Plugged heads.	Miscellaneous.	Total.
Elevators, Grain	1	5	5	..	3	..	2	1	..	3	2	..	1	23
Excelsior Factories	..	..	2	..	1	..	..	..	1	..	..	..	..	4
Fertilizer Plants	2	1	..	..	1	..	..	..	..	..	..	..	..	4
Flour and Grist Mills	6	3	1	..	1	..	1	1	2	4	2	..	2	23
Forge and Smithy	..	..	..	..	..	..	..	1	..	..	..	..	..	1
Foundries	11	1	1	..	..	..	1	..	..	2	..	..	..	16
Fur Mfg.	..	..	..	..	..	..	1	..	..	..	..	..	1	2
Furniture Factories	28	19	6	3	1	..	4	10	11	1	4	2	2	91
Furniture Stores	4	..	..	..	..	..	1	..	..	..	..	..	..	5
Garages	4	..	..	..	..	..	..	2	..	..	..	..	1	7
Garbage Reduction Plants	1	..	..	..	..	..	..	..	..	..	..	..	..	1
Gas Works	..	1	..	..	..	..	..	..	..	..	..	..	..	1
Glass Factories	2	3	2	1	..	..	2	1	..	..	..	..	3	14
Glove Factories	1	..	..	..	..	..	..	..	..	..	..	..	..	1
Glue Factories	1	..	..	..	..	..	..	..	1	..	..	..	..	2
Groceries	4	..	1	..	1	..	1	..	1	1	..	..	..	9
Hardware Stores	1	..	..	..	..	..	..	..	..	..	..	..	1	2
Harness and Fancy Leather Mfg.	..	..	1	..	..	..	..	..	..	..	..	..	1	2
Hat Factories	4	3	1	..	1	..	..	1	..	..	..	..	2	12
Hatters' Fur Works	4	..	1	..	..	..	1	..	..	..	..	..	..	6
Hotels	1	..	1	..	..	..	..	..	..	..	..	..	..	2
Idle Property	11	..	..	1	..	..	..	..	1	..	..	..	..	13
Institutions	..	..	..	..	1	..	..	..	..	..	..	..	..	1
Insulated Wire Works	..	1	..	..	..	..	..	..	..	..	..	..	..	1
Jewelry Factories	2	1	..	2	..	..	1	..	..	..	..	..	..	6
Junk Shops	1	..	..	..	..	..	..	..	..	..	..	..	..	1
Knitting Mills, Cop Yarn	1	1	3	..	..	..	..	1	..	1	..	..	..	7
Knitting Mills, Full Process	8	10	5	1	1	..	1	..	..	1	..	..	..	27
Laundries	2	..	1	..	..	..	..	1	..	..	..	..	..	4
Lead Pencil Factories	..	..	..	..	..	..	..	..	..	1	..	..	..	1
Linseed Oil Works	1	1	..	..	..	..	1	..	1	2	..	1	..	7
Macaroni Factories	2	..	..	..	..	..	..	..	..	..	..	..	..	2
Machine Shops and Works	15	5	1	1	..	1	..	..	..	1	..	..	..	24
Match Factories	2	..	..	..	..	..	..	..	1	..	..	..	1	4
Mattress Factories	8	2	..	1	..	..	..	2	..	..	..	..	..	13
Mercantile (Miscellaneous)	10	6	1	2	..	..	3	..	..	1	4	..	2	29
Metal Workers†	20	16	3	..	..	2	5	2	5	4	2	2	4	65
Mining Property	..	1	..	..	..	..	..	..	..	..	..	..	..	1
Miscellaneous	3	4	2	..	1	1	3	..	5	1	2	..	4	26
Morocco Leather (see also Tanneries)	5	3	..	..	2	..	1	..	..	..	..	..	1	12
Motion Pictures (Theatres, Studios, Exchanges)	2	1	..	..	..	..	..	..	2	..	1	1	..	7
Multiple Occupancy	..	..	..	..	..	..	1	..	..	1	..	..	..	2

	Water shut off sprinklers.	Generally defective equipment and unsprinklered portions.	Defective water supply or supplies.	Sprinkler system crippled due to freezing.	Slow operation of dry system or defective dry valve.	Slow or defective operation of high test heads.	Faulty building construction, concealed spaces, vertical openings.	Obstruction to distribution.	Hazard of occupancy too severe for average sprinkler equipment.	Sprinkler system crippled by explosion.	Exposure or conflagration.	Plugged heads.	Miscellaneous.	Total.
Munition Plants	2	..	..	1	..	..	..	..	4	1	..	..	1	9
Musical Instrum't Factories	1	4	..	..	..	..	1	..	..	..	1	..	..	7
Oil Cloth & Linoleum Works	..	6	..	..	..	..	1	3	12	..	..	..	..	22
Oil Clothing Factories	..	..	..	..	..	..	..	..	..	..	..	..	1	1
Oil Refineries—Vegetable	1	..	1	..	..	..	..	..	..	..	..	..	..	2
Packing Houses	1	2	1	..	2	..	..	..	1	1	..	..	1	9
Paint and Varnish Works	2	3	5	..	..	..	3	..	1	..	..	..	..	14
Paper Box & Paper Products	5	1	..	..	1	..	..	..	..	..	..	..	..	7
Paper Coating Mills	1	..	..	..	..	..	..	1	..	..	..	..	..	2
Paper Mills	24	22	12	3	1	3	2	2	4	3	2	1	13	92
Patent Leather (see also Tanneries)	1	..	1	1	..	..	1	..	..	..	1	..	..	5
Phonograph Works	1	..	..	..	..	..	..	..	..	..	..	..	..	1
Photograph Establishments	1	..	..	..	..	..	..	..	..	..	..	..	..	1
Picture Frame Mfg	1	2	1	1	..	..	..	1	..	..	..	..	..	6
Piers and Wharves	..	1	1	..	..	..	..	..	..	..	..	..	..	2
Potteries	2	1	1	1	..	..	..	..	..	1	..	..	..	6
Printing and Lithographing	8	4	1	..	..	..	1	1	1	..	3	..	1	20
Pulp Mills	10	4	4	..	1	1	1	..	1	1	..	..	2	25
Pyroxylin Plastic Mfg. and Fabricating	3	1	3	1	1	..	2	2	11	5	2	..	..	31
Radios and Accessories	1	..	..	..	..	..	..	..	..	..	..	1	..	2
Railroad Property	..	..	..	..	..	..	..	..	..	..	..	1	..	1
Restaurants	1	1	..	..	..	..	1	..	..	..	..	..	..	3
Rice Mills	..	1	1	..	..	..	..	..	..	..	..	..	..	2
Rolling, Wire & Tube Mills	..	..	..	..	1	1	1	..	..	..	..	..	..	3
Roofing Works	3	2	..	1	..	..	1	1	..	1	..	..	..	9
Rubber Cloth Factories	2	..	..	..	..	..	..	..	..	..	..	..	1	3
Rubber Reclaiming Works	2	..	..	..	..	..	1	1	1	1	..	..	..	6
Rubber Mills	8	..	..	1	..	..	..	1	5	4	..	1	1	21
Saw and Planing Mills	13	12	3	..	5	1	6	2	4	..	5	1	4	56
Ships and Shipyards	1	..	..	..	..	..	..	..	..	..	..	..	..	1
Shoddy Mills	6	3	6	..	1	3	1	1	..	..	..	..	1	22
Shoe Factories	15	6	3	..	..	1	..	2	..	2	5	..	3	37
Shoe Mfg. Accessories	1	2	..	..	..	..	..	..	..	..	..	..	1	4
Silk Mills	2	1	..	..	..	..	..	..	..	1	..	..	1	5
Skin Mfg. (see also Tanneries)	..	..	..	..	1	..	..	..	..	..	..	..	..	1
Soap Mfg	1	1	..	..	..	..	..	..	..	..	..	..	..	2
Stamping & Sht. Metal Wks	2	4	1	..	1	..	2	1	..	1	2	..	1	15
Starch and Glucose Works	..	..	..	..	..	..	..	..	1	7	..	..	..	8
Sugar Refining	1	..	..	..	..	..	..	..	..	1	..	..	..	2
Tanneries	1	1	..	3	..	..	..	..	1	..	1	..	1	8
Tenant Buildings	35	8	2	3	1	..	3	1	1	..	6	..	3	63
Theatres	3	3	..	..	..	..	..	..	..	..	..	..	..	6

	Water shut off sprinklers.	Generally defective equipment and unsprinklered portions.	Defective water supply or supplies.	Sprinkler system crippled due to freezing.	Slow operation of dry system or defective dry valve.	Slow or defective operation of high test heads.	Faulty building construction, concealed spaces, vertical openings.	Obstruction to distribution.	Hazard of occupancy too severe for average sprinkler equipment.	Sprinkler system crippled by explosion.	Exposure or conflagration.	Plugged heads.	Miscellaneous.	Total.
Tobacco Factories	1	1	..	..	..	..	..	..	..	..	1	..	..	3
Trunk Factories	2	1	..	..	..	..	..	..	..	..	..	..	..	3
Umbrella Mfg.	..	..	..	..	..	..	..	..	1	..	..	..	..	1
Vacant Buildings	1	..	..	..	..	..	..	..	..	..	..	..	..	1
Wall Paper Factories	..	..	1	..	..	..	..	1	1	..	1	..	..	4
Warehouses	15	4	3	..	3	..	1	4	2	..	..	..	4	36
Waste and Batting Mills	6	4	3	1	..	1	..	2	2	..	..	..	1	20
Waste Paper and Rag Shops	4	1	..	..	..	..	..	..	..	..	..	..	1	6
Weaving Mills	1	2	2	1	..	..	..	1	..	..	..	..	..	7
Window Shade Factories	..	..	..	1	..	..	..	..	1	..	..	..	..	2
Woodworkers, Class A*	12	9	4	..	1	1	1	6	..	3	3	1	4	45
Woodworkers, Class B*	6	8	2	2	..	2	1	1	..	3	2	..	3	30
Woodworkers, Class C*	5	4	2	..	..	..	..	3	..	..	..	..	..	14
Woodworkers, Class D*	2	9	..	1	1	..	..	..	..	2	4	..	3	22
Woodworkers, Class E*	5	2	1	..	2	1	2	..	..	..	1	..	..	14
Woodworkers, Class F*	2	..	1	..	..	..	..	1	..	..	..	..	..	4
Woolen Mills	17	18	14	1	..	2	4	..	1	..	3	..	9	69
Wool Scouring Plants	..	1	1	..	..	..	..	..	..	..	..	..	..	2
Wool Storehouses	..	2	..	..	..	..	..	..	..	..	..	..	..	2
Worsted Mills	3	3	2	1	..	..	1	..	..	..	..	..	4	14
Total Unsatisfactory Fires	538	332	153	44	47	25	86	93	101	81	74	15	128	1717

*The Woodworkers are classed as follows:

Class A. Interior Woodwork, builders' supplies (including veneer works).

Class B. Box Factories (including cigar boxes).

Class C. Miscellaneous Woodworkers. Steam power tenant Woodworkers. Woodworkers where there is a lack of detailed information as to class.

Class D. Sash, Door and Blind Factories.

Class E. Hard Wood Turning (wheels, pipes, novelties, bobbins, spools, etc., last and wood heel factories).

Class F. Pails and Woodenware (plates, wooden bowls, tubs, etc.).

†Other Metal Working Occupancies are included under Agricultural Implements; Automobile and Bicycle Factories; Bolt, Nut and Screw Works; Electrical Appliances; Forge and Smithy; Foundries; Machine Works; Rolling, Wire and Tube Works; and Stamping and Sheet Metal Works.

VOLUME XXII. INDEX.

	Quarterly No.	Page No.
A		
Acetates, Classification of	3	280
Acetic Acid, Classification of	3	280
Acetone, Classification of	3	280
Advertising in the Quarterly. *Editorial*	1	7
Airplane Fires, Experiments of U. S. Army Air Corps	1	70
Airplanes and Hangars—Fire Record	2	168
Editorial	3	235
Albany, N. Y., Film Fire, Memorial Hospital	1	68
Alcohol Plant Fire, New Orleans, La. *Louisiana Rating and Fire Prevention Bureau*	2	222
Alcohols, Classification of	3	280
Alexander Industries Fire, Englewood, Cal.	1	89
Aniline, Classification of	3	280
Auckland, New Zealand, Petrol Store Fire. *R. G. Butcher*	2	191
Automatic Sprinklers. *See Sprinklers*		
Aviation Committee, Creation of	4	365
Aviation Fire Hazards. *See also Airplane*	2	161
B		
Baltimore Clears Her Gangways. *Editorial*	4	358
Baltimore County, Md. McDonough School Fire. *W. C. Todd*	3	348
Barn Fires, Mysterious. *David J. Price*	2	176
Belt Dressings for Eliminating Static. *P. W. Edwards and J. O. Reed*	4	400
Benzaldehyde, Classification of	3	280
Benzol, Classification of	3	280
Blower Systems, Amendment to Regulations	4	363
Boston Paint Warehouse Fire. *Photograph*	4	356
Brick Joisted Buildings, Fire Test of	1	62
Bridge Fire, Memphis, Tenn. *Tenn. Inspection Bureau*	2	182
Building Fires. Tests of the Severity of. *S. H. Ingberg*	1	43
Buildings, Standard Industrial, Amendments to regulations	4	361
C		
Canadian Fire Losses, 1927. *Dominion Fire Prevention Association*	1	34
Carbon Dioxide Fire Protection. *Robert S. Moulton*	2	145
Carbon Disulphide, Classification of	3	280
Cascia Hall School Fire, Tulsa, Okla.	1	42
Chicago Salvage Patrol School	3	244
Children and Matches. *Editorial*	2	131
Children Prefer Firecrackers. *Editorial*	1	9
Classification of the Hazards of Liquids. *A. H. Nuckolls*	3	258
Concord, N. H. Wood Shingle Roof Fire	1	87
Cotton Seed Oil, Classification of	3	280
Crisfield, Md., Conflagration. *Underwriters' Association of Middle Department*	1	93
D		
Detroit, Mich., Fireworks Legislation	1	10
Dressings, Belt, for Eliminating Static. *P. W. Edwards and J. O. Reed*	4	400
Drill Schools for Small Communities. Activities of the Michigan Inspection Bureau	4	367
Editorial	4	358
E		
Editorials	1	5
	2	129
	3	235
	4	357
Electrical Code, Its Origin and Development	2	140
Electrical Equipment Sales, Control of, in City of Portland, Ore. *F. D. Weber*	1	38
Englewood, Col., Alexander Industries Fire	1	89
Ether, Classification of	3	280
Executive Committee Action	2	134
Executive Committee Meetings:		
May 7, 1928	1	16
January 22, 1929	4	361
F		
Fighting Fires Beforehand. *C. W. Mowry*	1	19
Film Exchange Fire Record. *Editorial*	2	132
Film Fire, Memorial Hospital, Albany, N. Y.	1	68
Film Vault Fire, Kansas City, Mo. *Missouri Inspection Bureau*	2	187
Fire Loss, U. S., 1927. *National Board of Fire Underwriters*	1	30
Fire Loss, U. S. 1927, Revised. *National Board of Fire Underwriters*	3	240
Fire Loss, Canada, 1927. *Dominion Fire Prevention Association*	1	34
Fire Losses, U. S. and Canada, 1928. *N. Y. Journal of Commerce*	3	242

	Quarterly No.	Page No.
Fire Loss Trend Continues Downward. *Editorial*	2	129
Fire Prevention Week Results. *T. Alfred Fleming*	3	248
Fire Record—Airplanes and Hangars	2	168
—Airplanes and Hangars. *Editorial*	3	235
—Fuel Oil Burners	1	96
—Garages	4	422
—Hospitals and Institutions	3	296
—Lake Superior Mine Fires	2	198
Fire Test of Brick Joisted Buildings	1	62
Fire Tests of Hollow Tile	4	407
Fires in Which There Was Loss of Life. *See Loss of Life Fires*		
Fires, Tank Car	4	380
Fireworks in Detroit. *Editorial*	1	10
Flammable Vapor Indicators	4	388
Fuel Oil Burners, Fire Record	1	96
Furfurol, Classification of	3	280

G

Garage Fire Record	4	422
Garage and Dance Hall Disaster, West Plains, Mo.	1	36
Gasoline, Classification of	3	280
Gasoline Explosion Wrecks Home, Salt Lake City, Utah. *Fireman's Fund Record*	2	138
Glycerine, Classification of	3	280
Gravity Tank Collapse, Knoxville. *Photographs from Tennessee Inspection Bureau*	4	415

H

Hazards of Liquids, Classification of. *A. H. Nuckolls*	3	258
Hexane, Classification of	3	280
Holland Vehicular Tunnel. *W. F. Steffens*	4	367
Hollow Tile, Fire Tests of	4	407
Hospital and Institution Fire Record	3	296
Hospital Film Fire, Memorial Hospital, Albany, N. Y.	1	68

I

Incendiarism and Arson. *Editorial*	1	11
Indicators, Flammable Vapor	4	388

K

Kansas City, Mo., Film Vault Fire. *Missouri Inspection Bureau*	2	187
Knoxville Gravity Tank Collapse. *Photographs from Tennessee Inspection Bureau*	4	415

L

Lake Superior Mine Fires. *F. C. Gregory*	2	198
Lard Oil, Classification of	3	280
Lawrenceville, Ill., Oil Refinery Fire. *Paul Truesdell*	2	218
Linseed Oil, Classification of	3	280
Liquids, Classification of Hazards. *A. H. Nuckolls*	3	280
Loss of Life Fires	1	122
	2	227
	3	351
	4	442
Lynn, Mass., Preble Box Toe Co. Explosion and Fire	3	289

M

Madrid Theatre Fire. *Chief Petersen, Düsseldorf, Germany*	3	251
Matches, Children and. *Editorial*	2	131
Matches, Safety. An Unusual Experience with. *D. H. Livingston*	2	148
McDonough School Fire, Baltimore County, Md. *W. C. Todd*	3	348
Memphis, Tenn., Harahan Bridge Fire. *Tennessee Inspection Bureau*	2	182
Methyl Salicylate, Classification of	3	280
Milwaukee,—Why Milwaukee Won the Fire Waste Contest	1	135
Mine Fires, Lake Superior. *F. C. Gregory*	2	198
Minneapolis, Minn., Washburn-Crosby Mill "A" Fire. *General Inspection Bureau*	3	341
Mysterious Barn Fires. *David J. Price*	2	176

N

National Electric Code. Its Origin and Development	2	140
New Orleans Alcohol Plant Fire. *Louisiana Rating and Fire Prevention Bureau*	2	222
Nitro Benzene, Classification of	3	280
Northern States Power Plant Fire. *James S. Mahan*	4	416

O

Oil Burner Fire Record	1	96
Oil Burner Regulations, Amendment	2	134
Oil Fires, Santa Fe Springs, Cal. *Lloyd Griffith*	3	283
Oil Refinery Fire, Lawrenceville, Ill. *Paul Truesdell*	2	218
Olive Oil, Classification of	3	280
Operation of the Holland Vehicular Tunnel. *W. F. Steffens*	4	373

P

Palm Oil, Classification of	3	280
Paramount Studio Fire. *Henry Anderson*	4	438

	Quarterly No.	Page No.
Petroleum Ether, Classification of	3	280
Petrol Store Fire, Auckland, New Zealand. *R. G. Butcher*	2	191
Portland, Ore., Control of Electrical Equipment Sales. *F. D. Weber*	1	38
Power Plant Fire, St. Paul, Jan. 3, 1928. *James S. Mahan*	4	416
Preble Box Toe Co. Explosion and Fire, Lynn, Mass.	3	289
Pyridine, Classification of	3	280
Pyroxylin Plastic, Regulations, Amendment	2	134
S		
Safety Matches, An Unusual Experience. *D. H. Livingston*	2	144
Salt Lake City, Utah, Gasoline Explosion Wrecks Home. *Fireman's Fund Record*	2	138
Salvage Patrol School, Chicago, Ill.	3	244
Santa Fe Springs Oil Fires. *Lloyd Griffith*	3	283
Sawmill Fire, Skykomish, Wash. *Washington Surveying and Rating Bureau*	2	214
School Fire, McDonough, Baltimore County, Md. *William C. Todd*	3	348
Tulsa, Oklahoma, Jan. 2, 1928	1	42
Schools, Fire Department, for Small Communities	4	367
Severity of Building Fires, Tests of. *S. H. Ingberg*	1	43
Skykomish, Wash., Sawmill Fire. *Washington Surveying and Rating Bureau*	2	214
Soot Removal. *Editorial*	3	238
Sprinkler Tables, Annual	4	445
Static Electricity, Belt Dressing for Eliminating. *P. W. Edwards and J. O. Reed*	4	400
T		
Tank Car Fires	4	380
Tank Collapse, Knoxville. *Photographs from Tennessee Inspection Bureau*	4	415
Telephone Fire Alarms. *Editorial*	1	13
Test of Brick Joisted Buildings	1	62
Tests of the Severity of Building Fires. *S. H. Ingberg*	1	43
Tests, Fire, of Hollow Tile	4	407
Theatre Fire, Madrid, Spain	3	251
Tile, Hollow, Fire Tests of	4	407
Toluene, Classification of	3	280
Traffic Ordinance, Baltimore. *Editorial*	4	358
Tunnel, Holland Vehicular, Operation of. *W. F. Steffens*	4	367
V		
Vapor Indicators, Flammable	4	388
W		
Washburn-Crosby Mill "A" Fire, Minneapolis. *General Inspection Bureau*	3	341
West Plains Garage and Dance Hall Disaster, West Plains, Mo.	1	36
Why Milwaukee Won	2	135
Wooden Shingle Roof Fires, Worcester, Mass. and Concord, N. H.	1	85
Worcester, Mass., Wooden Shingle Roof Fire	1	85
X		
Xylene, Classification of	3	280